THE CONTINUING OF ORGANICISM: AN ENVIRO-ORGANIC FORM INTEGRATING TO THE BUILT ENVIRONMENT

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ABSTRACT

Humans have engaged nature as an ideal paradigm of form and function since time immemorial. Within the organic paradigm, architecture may be seen to constitute an organic relationship with nature in any climatic, cultural and social condition. Though often rejected in canonical modern architecture, organic forms have been manifested, in various forms, and with different purposes. Recently, some modern organic movements have emerged, such as those following principles of biomorphic form and bio-mimicry. Unfortunately, these movements often fail to more fully embrace organicism in the totality and depth of their relationship to the natural.

Following D'Arcy Thompson's *On Growth and Form*, this research aims at uncovering the key attributes of natural form, in order to allow the design of enviro-organic form. Such form is defined as one that opens to the natural world, facilitating the making of architecture that sustains human life and nature today and in the future. In order to carry this out, the research offers graphic and analytic tools that help aid understanding into what organic architecture is, and how we can undertake a design process leading to enviro-organic form.

The research concentrates on the analogies between architectural form and natural forms. The outcomes are, to paraphrase D'Arcy Thompson, explained by the, "equilibrium resulting from the interaction or balance of forces."[1] Natural forms result from the fitness of the resolution of inside and outside living forces. Similarly, architectural organic form, as embodied in indigenous or vernacular architecture, result from integrating

[1] D'Arcy Wentworth Thompson, "Introductory," in *On Growth and Form* (Cambridge: University Press, 1942), 16.

environmental and socio-cultural forces. Because architecture must adapt to cultural and social changes, human built environments are argued to be functionally more complex than those made by animals, as seen for example in a bird-nest, spider-web, or ant-hill. Since vernacular architecture is largely shaped by instinct, and in response to specific local place and culture, vernacular forms are not typically suited to be applied directly to the needs of contemporary culture. Geometry is proposed as the medium for historical examination of the incidental analogy between nature and organic architecture, for the rational fitness of integrating between natural principles and architecture disciplines, and for the selective transformation of enviro-organic forms that promise to more fully integrate the works of humans into the natural environment.

Keywords: organicism, enviro-organic form, analogy, natural fitness, rational fitness, socio-cultural forces, environment forces, transformation, nature environment, built environment

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INTRODUCTION

The issue approach

Source of architectural imitation

Nature has been a key inspiration for human beings in the design and construction of buildings at all times and places. The influence of nature on humans not only includes its actual and perceived forms, but also its material energy, information channels, and processes. Humans are not only dwellers on the earth, but also transformers of the earth through their incursions into nature in order to adapt it to their purposes. Learning from nature thus is defined as organicism, which involves the imitation of nature, including the operations of mimesis and metaphor. It is considered as a purposive strategy or the conceptual tool of architectural form making. Organicism is not employed and developed as a science, but is framed as a guide for the creative process, and for the interpretation of art and architecture.

When humans interacted with nature, natural phenomena were observed and applied to the way people built their structures. The organic features of the surrounding environment were imprinted on their shelters. Thus, human building was informed with intuitive and theoretical models of living structures, such as organization, adaptation, selection, transformation, simplicity, complexity, and diversity.

Following Darwin's theory of evolution, organic architecture originated from human selection in interplay with nature. In certain stages, each of the organic types is born, with different names, evolving successful attributes and fixing the weaknesses of previous forms, in order to adapt to and fit human demands in relation to natural conditions. According to Thompson, this fit would result from "equilibrium is explained by the

interaction or balance of forces"[2]. The motivations in making form are simplified and converted to physical forces, and able to be visualized. Different intensities of those agencies in each case result in a specific form. The form becomes a diagram and record of dynamic processes in nature's growth. Therefore, by understanding the natural process leading to form, we can direct a conscious human process of design and construction leading to practical and artistic objects.

The similarity consolidates its position when, in his famous work, *On Growth and Form*, Thompson also argues that natural forms, such as plants and animals, could be understood in part by using mathematics, typically geometry, through description and analysis. He discloses the world as a symphony of forces and geometries, witnessed in dynamic growth and physical processes. The laws that govern an organism's dimensions and development are codified in the growth of cells and tissues. The processes comprise the phenomena of packing, membranes under tension, symmetries, and division of single cells, as well as engineering and geodesics of simple organism skeletons. Thompson's work had a strong influence on modern architecture between the world wars. It opened a line of reasoning that Abbé Laugier expounded in his discourse on the "Primitive hut". He argued in the 18th century that organicism is a basic instinct of man. Thompson's theories also link to architectural theory in the 19th century. Ideas by Ruskin, Viollet-le-Duc, and others, sought to unite scientific, aesthetic, and spiritual knowledge via developments in science, biology, and mathematics. These lines of thought link architectural principles with evolutionary processes of nature, and established two formal typologies in modern architecture: *rational-empirical* and *pure organic* form.

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[2] Thompson, "On Growth and Form," 22.

The historical development of organicism can be defined three stages: prehistoric (or animism), classic (mythology), and modern. In the first period, humans depended on nature and an architecturally organic manifestation that may be referred to as primitive organicism. This is seen in the form of simple structures, such as primitive huts, tents, cave dwellings, and monumental works such as Dolmen and Stonehenge. In the mythological period, humans admired and discovered the natural world. This way of thinking produced imitative natural shapes including structures and ornaments. They are developed according to three types of organicism in the successive order: tectonic, religious, and scientific. In the last period, beginning in the early 20th century, humans developed knowledge in the natural sciences and construction technology. Organic manifestations in architecture were produced by interpreting nature's laws and tempering these with social and cultural factors. In the early modern period, organicism (officially termed Organic Architecture) is divided into the types of mechanical and traditional organicism. From 1960s, the mechanical type becomes divided in two types: regional and high-tech organicism. In turn, these two types converge to high-tech organicism, also referred to as bio-mimetic architecture. This line of development sought to achieve a higher level of comfort, protection, and energy efficiency. In contrast, traditional organicism continued with the only purpose of integrating buildings formalistically into the natural environment.

It may be argued that organicism is a constant line of thought in the historical development of architecture. At times, the line of thought diverges from the main principles and becomes involved with interests in digital technology and ecological design. Today we are faced with finding proper relationships between traditional culture

and global culture. Each culture holds a particular constellation of factors and forces that influence architectural form.

Architecture should be free from our prejudices to follow our instincts and creativity, but tempered with logic and understanding of the senses. Organicsm in general seeks to produce a new true form as natural form that is deeply interconnected with its natural context. Organicism, like our understanding of nature, seeks form that is simple and complex, arbitrary and orderly, and with the inside related and linked to the outside. The promise of a new organic form is the integration of humans to nature, via interwoven connections.

What "organic" means in architecture

In architecture, "organic" means the imitation of nature. The organic idea of the imitation of nature is transferred to architecture by two means: the close connection between architecture and living nature, and the organic unity modeled on the functional correlation of the parts of living organisms. The term "organic" is commonly defined as an organ or the organs of an animal or plant. Its definition also consists of something pertaining to or derived from living organisms. Further, it connotes a class of chemical compounds that contain carbon. Organic form is considered to possess a systematic arrangement of parts, formed by growth processes, and embodied in animals and plants.

There is a difference between "organic", as it is commonly defined and referred to as Organicism, and the relation between humans and nature via Organic Architecture. One approach taken in the line of Organic Architecture's development is to imply the spirit of growth in nature by using geometry in ornament and composition. This commonly springs from the human perception of nature and traditional culture. In architectural

history, the meaning of organicism is succeeded or divided. For example, the notion of organicism in the early modern period is defined as a “mechanism”, and also as “organicism of tradition”.

The early modern architect Louis Sullivan is often credited for first coining the term “Organicism”. He sought to develop organicism within the whole of organic architecture, in which there is a unity of form and function, and a relation of the parts to the whole. His forms is emphasized the harmony between singular objects and traditional ornaments. Sullivan proposed that organicism relies on the organization or compatibility of parts that constitute the entire building and its site.

Frank Lloyd Wright followed Sullivan’s approach toward organic architecture, and evolved it based on influences including traditional Japanese construction. Wright endeavored to produce forms as products of their place and their time, without an imposed style, and intimately connected to the particular attributes in the context of its natural site, such as daylight, plants, and water. His buildings function by arranging rooms to each other and the site in a manner analogous to cohesive organism where the parts are integrated to the whole.

In *Towards an Organic architecture*, Bruno Zevi makes the following classification of what comprises either Organic Architecture or Inorganic Architecture. Zevi was influenced by Walter Curt Behrendt’s ideas. In Zevi’s classification, there are opposed terms stated, and describes the relation that Behrendt defines as the ‘dualism of the creative spirit’[3]

[3] Bruno Zevi, “Meaning and Scope of the Term *Organic* in Reference to Architecture,” in *Towards An*

	Organic Architecture	Inorganic Architecture
1	Formative art	Fine art
2	Product of intuitive sensations	Product of thought
3	Work of intuitive imagination	Work of constructive imagination
4	In close contact with nature	Contemptuous of nature
5	The search for the particular	The search for the universal
6	Delighting in multi-formity	Aspiring towards rule, system, law
7	Realism	Idealism
8	Naturalism	Stylism
9	Irregular forms (medieval)	Regular forms (classic)
10	The structure like an organism that grows in accord with the law of its own individual existence, with its own specific order in harmony with its own function and with its environment, like a plant or any other living organism.	The structure like a mechanism in which all the elements are disposed in accord with an absolute order, in accord with the immutable law of an a priori system.
11	Dynamic forms	Static forms
12	Forms based on freedom from geometry	Forms based on geometry and stereo-geometry
13	Product of common sense (native architecture), of 'reasonable beauty	
14	Anti-composition	Composition
15	Product of contact with reality	Product of education

Table 1. Organic and inorganic Architecture

Zevi deems the natural growth of things as an organic process and its result depends on the way of our thinking. He offers a contrast of approach through two examples, that of the European peasant, and that of the American laborer to illustrate their organic attitude in house construction. The peasant thinks of his house as a cube or as something relating to simple geometric form, built larger than needed, and with room left to be used later for his grown-up children. In this case, the growth of his house is ascribed to a definite program and constrained to the framework of a geometric design. The laborer follows a

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Organic Architecture (London: Faber Faber, 1982), 69-70.

different way by building one room, then a second, later a third, and so forth, as time goes on, to satisfy his progressively changing needs.

According to Zevi, this attitude is organic because it is, "more evolutional and closer to natural growth,"[4] and the exterior forms are derived from the interior space. He further suggests that the work of Le Corbusier, Walter Gropius, Alvar Aalto, and Greek and Gothic architecture should be considered as organic architecture because their forms result from a process, and they engage function to adapt to changed conditions.

Zevi also states that "organic" cannot be defined precisely, and brings forward two fallacies of so-called organic form. The first is the naturalistic fallacy where designers merely imitate the outer forms of nature, such as witnessed in *Art Nouveau* decorations. The second is the biological and anthropomorphic fallacy where designers copy biological structures and forms of the human body. He argues that designers err in positing organic form as consisting only of curved or flowing forms. In contrast, he states that architecture should be a partial and habitual extension of the human body by means of innate identification and remembered experience to the organic life world. Architecture organic is moveable and dynamic. Organic forms cannot be achieved by surface decoration in the Art Nouveau manner, nor by composition, as for example seen in the pin-wheel arrangement of the Bauhaus building floor plan. An organic spatial arrangement corresponds to the human dweller's actual movements. Thus organic form should be derived not only from technology, but also by human activity and emotional response.

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[4] Zevi, "Towards an Organic Architecture," 72.

> *"Architecture is organic when the spatial arrangement of room, house, and city is planned for human happiness, material, psychological and spiritual. The organic is based therefore on social idea and not on a figurative idea. We can only call architecture organic when it aims being human before it is humanist."*[5]

In conclusion, organic architecture is defined as the harmonious spatial organization of the parts within the whole, following to purpose, structure, and material. In the unity, there is no insignificant ornament or superfluity. The parts accord to the structure of the whole in which it reflects the structure of nature as growth. All are in a rational elegance of things intended for use. The form appears as a record of its coming into being, and the forces that shaped it.

Research contribution

This research intends to further the understanding of organicism as the historic source of architectural forms. Organic architecture acts as a junction between humans and nature, where humans are seen as parts of nature. Through organicism as an apparatus, designers are able to respond to nature in such manner that humans are more intimately bound into the entirety of nature to form an organic whole. A new term "enviro-organic" is proposed in this research. Enviro-organic form extends prior definitions of organic architecture which are argued to be of greater relevance today.

The architectural problem is understood to be driven by an analysis of the forces that act to give particular definition to form. The proposed methodology intends to aid designers with analysis using a three-dimensional (3D) approach, such to link form, function, and aesthetics. Diagrams of the forces can be programed in the computer, and they may be

[5] Ibid., 76.

output in various representations or actual constructions, such as by using 3D printing.

An investigation of architectural and natural structure aims to systematize and realize architectural geometries and natural geometries, including symmetry and asymmetry, growth patterns, and group form. It is intended that these methods will be useful for students and designers, and thereby contribute to the sustainable design and development of architecture.

Research objective

An enviro-organic form

In the 20th century, in concert with technological and industrial developments, many schools of thought emerge and evolve. Among those, modern architecture dominates and becomes the mainstream because of its preeminent theory of function. The Classical organicism is seen to be no longer relevant within secular humanism, and the rise of scientific method. However, this worldview is not monolithic, and there remain some architects that have continued the project of "Organic Architecture". From the middle of the 20th century, the mechanistic world view is gradually replaced by Einstein's theory of relativity and quantum theory. In this context, different from traditional organicism, organic forms are no longer considered as objects separated from their locations in space and time. Concepts of space-time, fractal geometry, and other concepts have influenced a return to organicism and a new impact on architectural design in 21th century. Concepts and definitions of organic form have an opening to be transformed in the light of this new paradigm.

The organic forms of nature are enmeshed in the life world of humans. Various applications and interpretations of nature cause many assumptions in organic

architectural forms. However, architecture as a unity of form and function is always organic, because it embodies the human impulse to question their relationship to nature in their endless quest to derive the meaning of existence in the world. Accordingly, enviro-organic form is born from humanity's internal and external needs in form, function and meaning, in which nature is the source of design. The organic is recalled in human memories of nature, not by perfectly reproducing nature's form, but reinterpreting and transforming natural form to constitute an organic understanding of life. Nature shares with architectural form its shapes, growth, unity and principles. Through metamorphosis, spirit, and body, living nature and form coexist.

Finally, humans are animals, living organisms that share common characteristics with other natural organisms. A system of form and function is changeable and responsive. At any moment of an altering process, disorganization becomes reorganized. The fluctuation purposes the formulation of an existent form on a higher level that corresponds to changed conditions. Thus, enviro- organic form consists of natural and rational processes that mediate the impacts of nature with human aspirations. Due to human consciousness and agency, enviro- organic form is born from an inorganic form and gradually evolves to a complex built organic form.

Targets

What architectural form best fits the spirit of the age? And how might we derive form that satisfies human needs of function and aesthetics vis-a-vis learning from and integrating to nature? To address these questions, this research focuses on:

a) Tracing the historical development of the concepts and definitions of organism as applied to organic architecture,

b) Defining the concept of enviro-organic form according to transformation of form,

c) Investigating the relation of the structure of nature and architectural composition,

d) Providing an approach and methodology to architectural design based on the concept of form growth

Methodology

To carry out the above mentioned targets the following four methods have been used:

1. Historical Research: To investigate the source and chronology of organicism, human and nature motivations on form, structure and architectural composition through historical periods of architecture, synthesize practical knowledge of existing buildings based on experience of natural principles and of the principles of architectural space, and discover key commonality of compositional structure between nature and architectural form,

2. Case Study Method: To evidence organicism in contemporary architecture, in selected works by Peter Eisenman, Frank Gehry, Frei Otto, and Nicholas Grimshaw that follow natural principles,

3. Logical Argumentation: To argue the relationship between nature and architecture convincingly, geometrical principles and fractal geometry are used to analyze natural structure and architectural form,

4. Descriptive Method: To analyze the geometry inherent in enviro-organic strategies in architectural form, function, and harmony impacted by nature, to systematize knowledge following logical argumentation in each case; and to build up the foundational design methods.

Current architecture

Organicism, form and function

Organicism is based on the premise that the universe is an orderly whole and alive. In architecture, it refers to complexity, individuality, imagination, and the relation to nature from inside to outside. According to the organic idea, function serves as the interactive functional network, with its form as the temporal dynamic network. Different from modernism architecture, organism denotes "form from function" and sometimes form goes beyond function to get the function of expression. In other words, form relies on function and they act mutually. Therefore, no single work of architecture may be deemed absolutely organic, functionalist, formalist, or expressionist. Depending on design orientation, each of those characters may be relevant to the building appearance.

Language and structure

In language, elements such as verbs, adjectives, adverbs, and articles are positioned relative to each other according to a grammatical structure. Similarly, partitioned architectural spaces are arranged relative to one another in particular ways, such as service space adjacent to served space, bathrooms close to bedrooms, and a forecourt in front of an entrance. In terms of meaning, there is the similarity between language and architecture in finding correct form by means of syntax to enhance the ordered relation of spaces and facilitate communication with other objects, concepts, and memories. Linguistic theory has informed architecture, and a recent example termed "Deconstruction", was described by Derrida in *Of Grammatology*. He argued that "the apparent rationality of a text inaugurates the, "destruction, not demolition but de-

sedimentation, the de-construction of its argumentation"[6]. The idea leads to a concept of structuralism in architecture. Architectural elements are taken in pieces and assembled in a new form.

Sustainable Architecture: The Green Concept

Today sustainable architectural trends are generally dubbed Green Architecture, offered with the purpose of protecting the environment and balancing the natural ecosystem. The values and principles animating Green Architecture may be found in ancient cultures in Egypt, Greece, and Cambodia, and traced in a timeline to Modern and Post-modern architecture by architects including Le Corbusier, Kisho Kurokawa, Patrik Schumacher, Peter Eisenman, Zaha Hadid, and Frank O. Gehry.

Traditional Principle versus Radical Principle

Symmetry is common attribute found in natural and human objects. While symmetrical balance is common, asymmetrical form is also present, and gives a counterbalance, displaying the existence of diversity in the world of forms. The basic geometries are derived from the shapes and motions of celestial bodies, which transform geometry into abstract form and nurture human's perception on the so-called beautiful mathematical forms. Mathematics and geometry are human constructs intended to reveal hidden patterns of order in nature. Some types of order have a much higher level of complexity than can be described by Euclidean geometry. Mandelbrot's Fractal geometry accounts for such complexity found in nature, such as topographic form and plant growth patterns.

Nature and Human Perception in Architecture

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[6] Richard Coyne. *Thinkers for Architects: Derrida for Architects* (New york: Routledge, 2011), 10

Humans have created buildings based on geometry. At times this is done with rational intension, and at other times, using intuition alone. We plan and think on some architectural design harmoniously, somehow like Plato said, *the world is just image of perception*, so in our memory, as well as in our mind, dynamic spaces, including natural elements, such as tree, water, sky, terrain, architecture, and people are enacted. Such dynamic spaces would naturally become architectural works with different levels if they are successfully grasped.

CHAPTER 1. HISTORICAL OVERVIEW OF ORGANIC ARCHITECTURE

1.1. The evolution of organicism to organic architecture

1.1.1. Mimetic organicism

Rhetorical and poetical interpretation

The idea of architectural organicism springs from rhetorical and poetical interpretations of works of art. This movement began in the context of art and architecture generated by the imitation of nature. The idea of the imitation of nature was a primary tenant in artistic theory from Classical Antiquity, the Renaissance, and continued in various strains up to the present. Rhetoric and poetics were taken as a conceptual apparatus to inform the visual arts and architecture. According to Caroline van Eck's study, in *Organicism in Nineteeth Century Architecture: An Inquiry into Its Theoretical and Philosophical Background*, organicism is defined as the imitation of nature. Architectural organicism provided a theoretical framework and guide for the creative process and interpretation.

The whole and its articulated parts

The earliest cases of rhetorical or poetical contexts connected to organicism can be seen, in Plato's *Phaedus* (370 BC), where Socrates compares the structure of speech to living beings, *'[a speech] should be like a living being, with a body of its own as it were, and neither headless nor feetless, with a middle and with members adapted to each other and to the whole*.'[7] Or in Aristotle's *Poetics* where he stated,

> *'Now about the kind of imitative art which is narrative and works in verse, it is clear that*

[7] Caroline van Eck. "Classical and Renaissance analogies between architecture and nature," in *Organicism in Nineteenth-Century Architecture: An Inquiry into its theoretical and philosophical background* (Amsterdam: Architecture & Natura Press, 1994), 41.

> *one should give the plots dramatic construction in the same way as tragedies, that is, center them around a single action which whole and complete and has beginning, middles, and end, so that like a single whole creature it may produce its proper pleasure. …'*[8]

When such comparisons or analogies between architecture and nature begin to be made in architectural theory, they are very similar to rhetorical or poetical comparisons that seek to identify a correlation of the parts to the whole.

The human body as exemplar of the harmonious whole

Vitruvius writes about sacred architecture, where nature is considered as God, and where God is reflected in the human body:

> *'No temple can have a systematic [or: reasoned] composition without symmetria and proportion, unless it has a precisely determined relation [ratio] of the members like that of a well-formed human body.*
>
> *If nature has made the human body in such a way that its members in their proportion correspond with his figure as a whole, the ancients seem to have determined with good reason that in the execution of buildings as well, these should possess an exact commensurateness [viz. based on the use of a module] which contributes to the aspect of the shape as a whole.'*[9]

Also, Vitruvius concentrates on the imitation of nature *vis-a-vis* the human body and its presumed proportions. He proposes – following Aristotle – that the human body is the ideal paradigm for architectural composition. The proportional unity and correspondence of the parts of the human body is described in the notion of the *homo quadratus*: the body

[8] Ibid.
[9] Ibid.

of a well-built man whose extended hands and feet fit into a square and a circle, which were considered to be the two most perfect geometrical figures. As is seen in the well-known Leonardo da Vinci's demonstration of *homo quadratus* , this ideal unity is a modular unity: a part of the body, such as the foot or the forearm, serves as the basic unit from which all dimensions derive through a process of multiplication.

Vitruvius argues that organicism is a natural characteristic of mankind. This is evident in the close connection between art and architecture, in which nature forms the core of its teaching.

Purposive unity: opposition, variety and aptness

The relation among nature, the human body, and architecture is explained in Alberti's treatise, *book IX of De re aedificatori*, first published in 1485, by the concept of *concinnitas*[10]. Alberti's work was perhaps the most influential theoretical discourse during the Renaissance, and it clearly presents the idea of the role of the human body in establishing the relation between architecture and nature. Cicero used the terms "close knit", "elegant joined" or "skillfully put together" to characterize a style deemed to be beautiful or elegant. Cicero states,

> *"Beauty is a form sympathy and consonance of parts within a body, according to definite number, outline, and position, as dictated by concinnitas, the absolute and fundamental rule in Nature. This is the main object of the art of building, and the source of her dignity, charm, authority and worth"*[11]

In order to describe his conception of nature as informing the unity in architecture,

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[10] Ibid., 45.
[11] Ibid., 46.

Alberti used four terms: concinnitas, opposition, variety, and aptness. In reference to the well-knit and skillful unity, the first term concinnitas is a regulative and unifying category that results from reconciliation of opposing and varying forms. The unity is based on its aptness, suitability, appropriateness, or fitness in adaptation to a purpose. Opposition or antithesis is stated to result in variety or *varietas*, creating an equilibrium from opposites, thus following a process observed in nature.

1.1.2. Imitative organicism

Ordering the whole: Obeying physics laws

In an effort to understand natural laws, Laugier (1753) proposed a thought experiment where a primeval man has recourse only to his natural instincts to satisfy his needs in his primitive environment. To shelter himself from heat, cold, and rain, the finds a solution, or tool, 'the small rustic hut'[12]. He made the hut by branches located at four corners of a rectangle or circle vertically, and on top of those four branches are placed at right angles. To make the skeleton for the hut, he continues to place flexible branches that meet at a point. The rudimentary roof is thus formed and then covered by leaves to protect from sun and rain. Through this example, Laugier presents a concept of organicism that concentrates on two distinct but connected meanings. On the one hand, 'nature'[13] means the whole of empirical reality which is not of man's creation, and which includes the laws of gravity and statics. On the other hand, Laugier presents the idea of man seen as part of nature, but who is – through the act of his intervening into nature with the invention of the hut – initiating a process of distancing from nature.

[12] Ibid., 89.
[13] Ibid., 91.

Laugier opens the revolutionary view of organicism that resides in two aspects. Firstly, organicism shifts from mimesis to imitation – or, in other words from the rhetorical and poetical category of the imitation of nature in works of art to a technical and scientific notion subject to the laws of physics. Secondly, he presents order as the essence of architecture, where the parts of the building are seen as the parts of the order. Accordingly, Laugier rejects ornament in favor of structure as the primary factor that determines the character and meaning of architecture.

Unity and growth under climate forces

The notion of organicism as a strategy of interpretation in architecture is developed in Goethe's attempts to understand the orders of classical architecture, such as the Greek and Minerva temples. He goes further with analogies linking forms of nature and architecture by presenting the concept of metamorphoses directed by mechanical Newtonian laws. Goethe investigates the varieties of formal transformations, termed "morphology". The essence of the formal development of animals is seen in their adaptation to their unique environment. Their growth and form are governed by a coherent system of laws which in turn determines their unique character. He proposed that symmetry and proportion are formal expressions of the autonomy which is a defining characteristic of every living organism. This autonomy is the result of the purposive unity of all its parts whereby their existence is completely bound up with the other parts and the whole which they together constitute. Goethe opens up the space for the consideration of architecture as structure that is characterized not only in terms of mechanical laws of gravity and statics, but teleological laws of functional correlation and purposive unity. For Goethe, mere imitation of the external appearance of nature only leads to superficial

effects. In *Simple Imitation of Nature, Manner, Style* (1789)[14], he asserted that style is one of the instruments by which the imitation of nature is transformed into art. To create art works, an artist has to penetrate into the inner being of things, as well as into his own inner being, in order to trace the methods by which nature develops.

Follow natural laws: Proportion and symmetry

Schlegel suggested two ways in which architecture can imitate nature: 1) in its practical and functional aspect it follows the laws of nature that regulate matter; 2) in its decoration, which is not subjected entirely to demands of utility, architecture imitates the forms of organic nature. In his new idea of organicism Schlegel stresses the opposition between organic nature which is alive, and inorganic nature which is lifeless. He proposed architecture should imitate nature's method, instead of its outer forms. Because architecture works with dead matter, it has to obey the mechanical and geometrical laws that govern its use, to satisfy the demands of architectural correctness, such as structural solidity. When this done, the architect has the freedom to design ornaments. For Shlegel, symmetry is another way in which architecture imitates the methods of nature, thereby presenting an analogy with organic nature, which concerns the building as a whole. His definition of symmetry differs from the Vitruvian sense of modular correlation of proportions. Rather, he defines symmetry as bi-lateral symmetry, where exactly similar parts are seen on either side of a dividing line. Shlegel notes this symmetry to be a distinctive formal property of higher animals and human beings. He links this idea to architecture when he asserts the use of symmetry and proportion as the expression of a fundamental, underlying purposive unity of a building. It is the sign of an independent,

[14] Ibid., 111.

complete and close whole, by which a building as a work executed by one indivisible design is recognized and, every part of which determines the others and is determined by them.

1.1.3. Organicism in modern movements

Geometric and physical laws

The notion of organicism as being fundamentally a unity is maintained and transformed in its relation to architecture in 20th century. This movement is called scientific organicism. In the second half of the 19th century, the two most prominent architectural theorists were Eugène-Emmanuel Viollet-le-Duc and John Ruskin. Their work influenced notable architects including Louis Sullivan, Frank Lloyd Wright, and Antoni Gaudí. Inspired by nature, Viollet-le-Duc advocated a scientific and rational approach to nature, based on geometric and physical laws, who defined architecture as a harmonious system of construction and composition. Similar to many 19th century theoreticians, he argued that architecture does not have to merely imitate natural form, but more importantly, to emulate its laws. Architecture should learn, e.g., the why animal skeletons and plant leaves and arranged as they are. He understood unity in nature depends on a complex mathematical, physical, and functional interdependence. The concept of harmonious geometric unity becomes a core premise for guiding form making in architecture in the 20th century.

Reflection of human's spirit on nature

In his work *The Seven Lamps of Architecture* (1849), Ruskin emphasizes the significance of handcraft, honest use of material in construction, and rational construction. He rejects mechanistic science and advocates forms that communicate a sense of energy and

movement. To Ruskin, buildings have to express the power of nature as the art of the Deity. Ornament and beauty originate from nature and should be designed to fit human needs.

Various more recent movements in architecture, including Modern, Postmodern, High-Tech, Critical Regional, and Rational continue in varied ways the use of organic principles. Geometrical forms are strictly composed and grounded on the foundation of the dictum, “form follows function”.

1.1.4. Organicism of pure Organic Architecture

The influence of rhetoric and poetics on concepts of organicism matured in modern architecture in the 20th century, and was renamed as “Organic Architecture”. Organicism had previously not been clearly defined because it was considered a poetic strategy for design invention and interpretation. Organic architecture was theorized to originate from nature, to provide an opening to nature with a spatial structure to satisfy a relation between form and function. Organic architecture can be considered modern architecture because of its concern with function. However, it’s philosophy differs from mainstream modern architecture in the ways each work is uniquely adapted to its natural context.

Parts act as the whole

The term “organic architecture” was first used by Sullivan, Wright’s first employer. In his *Kindergarten Chats* (1918), Sullivan seeks to find the true meaning of “Organic Architecture” by first exploring the definition of “organic”. He defines “organic” as living and development, therefore growth. His idea implied the, “initiating pressure of a living force and a resultant structure or mechanism whereby such force is made manifest

and operative"[15]. If the work is to be organic, the function of the parts must have the same quality as the function of the whole. For Sullivan, "organic" stands for searching for realities, in which thinking and feeling approach coincidence. He is well-known with his axiom "form follows function."

Organic form responding to site conditions

Under the influence of Viollet-le-Duc's work *Dictionnaire raisonne de l'architecture francaise du XIe au XVIe siècle* (1856) and Sullivan's notion of organicism, Wright understood that architecture should explore historical principles of architecture and nature. With his knowledge of Japanese art and traditional architecture, he found his own concept of organic form as consisting of unity, harmony, and simplicity. He believed in understanding and respecting the specific site context, including its natural condition and cultural condition. Thus, the building becomes a frame or filter in relation with its environment, bringing the outside into the house and projecting the inside to the outside. Wright's buildings expressed the organic connection to nature by horizontal lines extending from the prairie landscape. His buildings seem to grow from the earth, and are connected to nature by terraces, covered garden walls, flower beds, and decorative containers. Wright connects architecture and nature, using a number of techniques, including, organic and geometric patterns, natural materials, and nside-outside connections. The Robie House in Chicago and the Fallingwater House in Pennsylvania are representative of his prairie and organic styles. For many, Wright is the true father of organic architecture and his organic concepts inspired generations of architects.

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[15] Zbasnik-Senegacnik, Martina and Kitek Kuzman, Manja."Interpretations of Organic Architecture", *Scientific Papers*, Vol. 2, No.22 (2014): 291-299.

Organic form as nature's static forces

Antonio Gaudí (1852-1926) was inspired by the abundant organic forms of nature, such as rushes, reeds, and bones. Gaudi was influenced by Viollet-le-Duc's idea of Gothic form as embodying the true fusion of the functional with the aesthetic. He does not integrate buildings to their natural surroundings by connecting to them with their interior. Instead, Gaudi discovered the principles of static forces in nature and translated these into to the structure of his buildings. Because of his admiration of natural variety and uniformity, he combines widely varied natural forms to derive unique forms of organic architecture seen in examples of his work, such as Guell Park and Casa Mila in Barcelona, Spain. Gaudí's form of organic structure influenced many modern architects, including Frei Otto, Pier Luigi Nervi, Oscar Niemeyer, and Santiago Calatrava.

1.1.5. The continuity of pure organicism

The geometry and composition of the whole

The exhibition of *The Continuous Present of Organic Architecture*, 1991, presented evidence that the line of organic architectural inquiry has persisted through history. The exhibition argued the case of organic architecture being born in the Midwest with practitioners Sullivan and Wright. The collection includes the works of six architects with overlapping ideals representing a distinctive branch of American organic architecture. The lineage begins with Louis Sullivan (1856-1924), continues with Walter Burley Griffin (1876-1937) and Bruce Goff (1904-1982), and two Goff's students: Herb Greene and Bart Prince, and concludes with Cincinnati architect Terry Brown.

Many different forms are taken from assertions of the natural, the functional, and the ecological, such as, "organic is curved, organic is asymmetrical, organic is natural

materials, organic is individualistic, organic is holistic, organic is not mechanical, and organic is good". What is the difference of those organic forms in the organic continuum? Bruce Goff quoted a passage from Gertrude Stein to identify the important characteristic of organic works:

> *'Everything is the same except composition and as the composition is different and always going to be different everything is not the same. So then I as a contemporary creating the composition in the beginning was groping toward a continuous present, a using everything a beginning again and again.'*[16]

According to the introduction of Sidney K. Robinson, organic architecture is a "Dionysian force" upsetting the control of reason and the propriety of convention. It does not deny them, but borrows reason for its power to challenge, and employs convention for its ability to encourage. Organic architecture can be considered the sensory correlation of rationalist architecture. The only biological message of organic forms in relationship with nature is the development of the individual that reenacts the development of the animal and plant species. In the midst of these organic collections, the continuity of geometry guides the free exploration of the past and the joyful engagement with the present. Geometry is the one constant that transcends individual time and space. It is traced from the workings of the cosmos and only appeared when convenience required. The exhibition establishes a viable continuing of traditional organicism: organic form of tradition in its preference for centralizing geometries, of non-tradition in its incorporation of geometric patterns, colors and materials that are not subordinated to an obviously dominant architecture expression.

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[16] Sidney K. Robinson, "The Continuous Present of Organic Architecture," in *The Continuous Present of Organic Architecture*, ed. Elizabeth A. Scheurer (Cincinnati: The Contemporary Arts Center, 1991), 15.

Growth and integrity as the whole and ornament

At Merchants National Bank in Grinnel, Iowa, 1914, Sullivan created spiral movements in a window ornament over the bank's front door. He integrates the whole building geometry in the ornament's geometric details [Figure 1].

Figure 1. The whole and ornament, Mechants National Banks, Iowa, 1914

Wright stated that he learned about the organic from Sullivan' ornament, instead his architecture as a whole. He grasped the integrity within the building itself and as it related to the natural world. As he said, 'Many years later as I lived, drew, and built, I found in what I conceived and drew the element I now call plasticity (the matter had rendered it so completely in clay) carried in its own nature implications of unexplored structural continuity.'[17] Most of Wright's early work is influenced by the architectural tradition of tightly integrated composition. Wright differs from Sullivan regarding the use of ornament. Sullivan emphasizes ornament to animate the building mass through its expression of the "virtue of differential growth"[18]. He uses the contrast between the whole and detail, and between dynamic and static to express his concept of form as the spirit of growth. Wright destructs the box but not to maintain and preserve the integrity of geometric identity, but merge into an "immediate continuity". At the Unity Temple, Oak Park, Illinois, designed 1906, Wright adds ornaments to the exterior columns ornamentation using geometry referencing the compositional building as a whole [Figure 2].

Figure 2. The growth spirit of column ornament, Unity Temple, Oak Park, Ilinois, 1906

[17] Robinson, "The Continuous Present of Organic Architecture," 18.
[18] Ibid.

The expression of growth as interweaving

Organic Architecture follows two lines of development, one in America and one in Europe. The American development follows Sullivan's or Wright's lead in form and underlying geometry, ornament, and composition to express different growth dynamics. The European development pushes organic principles beyond what was done by Sullivan and Wright. In Europe, geometric principles of physical forces, including static and dynamic force were applied, resulting in a synthesis of architectural and structural form, as best exemplified in Gaudi's works.

Griffin's work follows Sullivan's idea of differentiated expression of the ornamental whole, in contrast to Wright's subordinated concept. However, Griffin's composition is influenced by Wright's Prairie houses style. The J.G. Melson House is one of his projects that display the singularity with its adornments. It is in cubic form, localized symmetry is used in the composition of forms, along with an ambiguous relationship between the man-made structure and its natural setting [Figure 3].

Figure 3. Singularity and adornment, J.G.Melson House, Mason City, Iowa, 1912

Goff developed organic architecture based on geometric forms. He sought organic forms, having greater freedom and variety. Goff was also influenced by Wright and Sullivan, as can be seen in his use of complex composition and decoration. A strong and independent geometry is laid onto the building mass or volume as seen for example in the Ruth Ford Residence, Aurona, Illinois, 1948 [Figure 4] and Eugene Bavinger House, Oklahoma, 1950 [Figure 5].

Figure 4. The growth of complex geometries, Ruth Ford Residence, Aurona, Illinois, 19448

Figure 5. The growth of singular volume, Eugene Bavinger House, Oklahoma, 1950

Herb Green also continued Sullivan's notion of the whole composition. Greene increasingly used a free architectural composition. He used graphic and pictorial patterns to relate between the identities of buildings and people. Prairie House, Norman, Oklahoma, 1960-1961 [Figure 6] and Cunningham Residence, Oklahoma City, 1963 [Figure 7] illustrate composition focused on cultural expression. His recent work with Bay Area sculptor John Toki seeks to connect ecological, aesthetic, and social factors.

Figure 6. Decentered Space, Prairie House, Norman, Oklahoma, 1960-1961

Figure 7. Concentrated composition and the growth of fa□ade, Cunningham Residence, Oklahoma City, 1963

Following Sullivan's *System of Architectural Ornament* along with the spirit of form growth, Bart Prince derives form from the application of organic principles of ornament. He transforms the spirit of natural growth on ornament to architectural composition with the geometric patterns found in the site. He makes his building forms from combined elements that he senses from natural phenomena such as windswept mound, dune, tree, mountain, etc. To integrate each building to its site, he incorporates local textures and colors. Such features are displayed in Robert Hanna Residence and Studio, Albuquerque, New Mexico, 1975 [Figure 8], the Pavilion for Japanese Art, Los Angeles County Museum of Art, 1978 [Figure 9], Joe and Etsuko Price Residence, Corona del Mar, California, 1985 [Figure 10], and Bradford Prince Residence, Albuquerque, New Mexico, 1987-1988 [Figure 11].

Figure 8. The interwoven geometries, Robert Hanna Residence and Studio, New Mexico, 1975

Figure 9. The growth of geometrical tradition, The Pavilion for Japanese Art, Los Angeles County Museum of Art, 1978

Figure 10. The growth of geometrical composition, Joe and Etsuko Price Residence, California, 1984-1996

Figure 11. The growth of the whole, Bradford Prince Residence, New Mexico, 1987-198

Brown continues Wright's concept of singular forms and Sullivan's spirit of ornament. He breaks the overall building mass into organic entities by angled slices of circles and arcs. His work relates to Prince and Gaudi in the way of integration. He enhances the dynamic aspects of nature by the use of colors, patterns, inclined roofs, and skin textures. The Coward Residence Addition, Cincinnati, Ohio, 1990 [Figure 12], Architectural Installation: Sunkawakantatanka 2, 1991 [Figure 13], and Mushroom House, Cincinnati, 1992-2006 [Figure 14], are typical examples of his design philosophy.

Figure 12. Acute angled elements, Coward Residence Addition, 1990, and Architectural Installation, Cincinnati, 1991

Figure 13. The spirit of growth at angled slices of circles and arcs, Mushroom House, Cincinnati, 1992-2006

1.2. The impact of organicism on form today

1.2.1. Still organic contemplation

Organicism, the process of growth in general, from mimesis to imitation of nature, focuses on how to make buildings similar to nature. Humans learn from nature and replicate and symbolize it. These strategies are not limited to Organic Architecture but are also seen in other modern architectural movements.

The ideas of the whole of geometric interweavement, tradition, ornament, and force based on natural principles as developed by Sullivan, Wright, and Gaudi have been continued and expressed by architects up to the present [Figure 14]. European architects

are influenced by these concepts to varied extents, and their organic forms are made by a following traditional design and local culture, such as Imre Makovecz's buildings: Sport Hall, Visegrad, 1985, Expo'92 Pavilion in Serville, Hungary, and Onion House, Mako, 1995. Other architects extend these ideas by considering landform and social context in their designs.

Figure 14. The continuing of organicsim

Some buildings are placed completely or partially below ground, such as EFA Radio Satellite Station, designed by Gustav Peichl, and Nine Houses, Dietikon, Switzerland by Peter Vetsch. The Eden Project, Cornwall, UK is an example of cells forming a whole interrelated to its site. In Asia, Truss Wall House and Soft and Hairy House designed by Eisaku Ushida and Kathryn Findlay are examples of primitive singularity in which nature is exploited by voids and complicated curved shapes. The development of organicism directed by consideration of physical forces is seen in architect Frei Otto's work. His Munich Olympic Park designed in 1972, is one of his attempts to align architectural/structural form with natural form.

1.2.2. Returning to on-earth

Modern architecture attempts, through a process of abstraction, to capture the great variety of natural forms. Certain modern architects, including Le Corbusier, Walter Gropius, and Peter Eisenman, have developed different interpretations of how to make organic architecture. However, their works do not directly show the relationship of natural forces and their impact to the architectural form.

Creativity is theoretically limitless but human creation itself is limited. A rationalist movement in architecture attempted to divorce buildings from nature. However, a

number of architects that previously held rationalist tendencies are starting to return to an appreciation of nature as inspiration for their designs. For example, Frank Gehry finds his relation with Bruce Goff late in his career,

> *"I knew of Goff in my architectural beginning as a shadowy mystical figure in Oklahoma who made bizarre buildings … Goff talked about the intuitive in a way that I find familiar. His discussion about connecting to the other arts, to music and painting, are more areas and coincidence. He expressed ides to their limits. He talks about awkwardness, irresolution, and the unfinished. These are all issues and ideas that move me also."*[19]

From the all observations above, humans still are looking for a new way for making form and organicism is tending to be translated to a new position. Some organic forms are inspired by the natural setting to blend their forms into rocks, fields, hills, and lakes. Other have used those images metaphorically, echoing the natural landscape, of caves, meadows, and forest. Others are inspired by abstract principles of natural structure, mimicking the way a tree that integrates strong trunks, hidden widespread roots, and delicate leaves into a single unity. Some others are inspired by the lateral shapes of flowers, birds, bones, and crystals. Henry Whiting Residence, designed by Bart Prince [Figure 15] and Desert House in California, designed by Kendrick Bangs Kellogg [Figure 16], Science City, International Competition 2016, First Prize [Figure 17], Second Prize [Figure 18], and Third Prize [Figure 19] are the notable examples of those characters.

Figure 15. Landscape integration, Henry Whiting Residence, Idaho, 1989-1991

Figure 16. Natural articulation, Desert House, Californiha, 2000

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[19] Alan Hess, "Organic Architecture Today," in *Organic Architecture: The Other Modernism*, pho. Alan Weintraub (Salt lake City: Gibbs Smith, 2006), 186.

Figure 17. Unified composition of Science City, Cairo, Egypt, the First Prize, Competition 2016, Weston William and partners

Figure 18. The organic whole of Science City, Cairo, Egypt, the Second Prize, International Competition 2016, Ngiom Partnership

Organicism does not stop at imitation of outside phenomena, but further seeks to learn their essence from their conformations and interrelations. Forms interact mutually between nature and the built environment. Figure 19 shows the lineage and development of organicism's impact on architectural form.

Figure 19. The continuing of organicism and prediction of form

1.3. Modern theory of form and tectonics

Form was related to currents seen in modernism, including its tectonic meaning in relation to culture and environment. The essence of form was thought to be influenced by the spirit of place. The truth of form and the meaning of form are two main ideas in recent architectural thought.

1.3.1. The truth of form

Form without ornament

Adolf Loos discusses the truth of architectural form vis-a-vis the relation between form and ornament. He argues that ornament is a crime. Loos believed ornament distracted people from true form that was reflective of the modern epoch. Ornament was seen as unhealthy, and a waste of labor, money, and material. Loos further argued that ornament impeded cultural progress. Instead, he believed that a pure form of architecture was the

"head of humanity"[20] and would further society and culture.

Form of standardization and rationalization

Walter Gropius suggested that true architecture has concrete expression and clear form to adapt to current economic and social conditions. He emphasized the use of modern materials, such as concrete, steel, and glass, over traditional materials. Steel allowed large spans, extensive daylight, and flexible use. With the help of steel, the structural system of a building was comprised of the foundation, columns, beam, and roof. The wall was released from the role of sustaining gravity forces. That leads to the development of prefabricated methods, with flexible interior space, and rapid construction to meet the demand for housing after the World Wars. Gropius concentrated on two core aspects in architectural design and practice: *Standardization*[21] and *Rationalization*[22]. The former met community need because of reducing construction cost. The later excluded nonessential aspects such as ornament, instead focusing on the logical order among building structural elements, such as floor-beams, wall-slabs, windows, door, staircases, etc. Gropius explained that the order of logic itself was the aesthetic of building. The logic itself contains proportion, and allows for repose, comfort, and perception of spatial harmony. Gropius' standpoint is based on social and psychological needs. Saving money in construction is used for upgrading building quality and human life, instead of unpractical problems such as styles and decorations. Gropius led the Bauhaus School, where artists and architect trained students in practical matters using handmade and

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[20] Adolf Loos, "Ornament and Crime," in *Ornament and Crime: Selected Essays*, Riverside, CA: Ariadne Press, 1998), 171.
[21] Walter Gropius, "Standardization," in *The New Architecture and the Bauhaus*, trans. P. Morton Shand, intro. Frank Pick (Cambridge: MIT Press, 1965), 30.
[22] Gropius, "Rationalization," 38.

machine methods. However, standardization, rationalization, and abstraction of the forms produced lead to abolishment of plurality and suppression local culture.

Form of memory

Juhani Palassma states the dominance of vision lead to the development of human knowledge and thinking based upon visual perception. He argues that with the increase in image production, humans have become increasingly emotionally affected given the "mesmerizing flow of images"[23] without focus and participation from other senses of their bodies. Hence the quality of architecture's true form depends on what those images present or are presented according to "narcissistic and nihilistic eye"[24]. Instead of architecture being centered on matters such as memory, existence, and of space experience, it is now instead focused on being a product for commercial consumption. Thus architectural form is separated from the truth of appearance. Architectural form itself is flattened into pictures, and has thereby lost a human *plasticity* of form, memory, and experience with the dominance of images, humans experience from outside as a spectator, seeing only he images projected onto the retina.

Humans have not always privileged vision over the other senses. Palassma argues that the shift from oral to written speech essentially results in a shift from sound to visual form. Hence, he claims rhetoric and poetry bring us back to oral world again. In other words, poetry brings back the true form that integrates humans to their environment, reconstructs our inner feelings of the living world "in which we are not mere spectators but to which

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[23] Juhani Pallasmaa, "Hegemony of The Eye and The Loss of The body," in *Thesis: Ars Imitatur Naturam*, ed. Heidemarie Scheirmer and Dorte Kuhlman (Bauhaus Universitat: Wissenschaftliche Zeitschrift, 1997), 110.
[24] Ibid., 109.

we belong inseparably."[25]

1.3.2. The metaphor of tectonics

Mimesis and imitation

True form of human settlements begins when they placed a first stone on the ground. Then another stone is placed on the first. The earth guides human activity until all the stones are in turn transformed into columns, walls, and roofs. This activity is tectonic and results in true form. It springs from the demand to grasp vital relations in the human and natural environment, to bring meaning and order into a world of events and actions. It does not come from primeval huts, caves, or local myths but from its surroundings, according to Vittorio Gregotti. From the site, new principles and methods can be seen for design. From the tectonic metaphor, human's two attitudes to the context are, "… mimesis or organic imitation, and display of complexity"[26], and "…assessment of physical relations or formal definition and interiorization of complexity."[27]

An order in right place

In *The Lamp of Truth*, Ruskin debates the true architecture and its makers and indicates organic relation and the unity of form, function, and material. He describes a logic where there is a reasonableness of elements in the whole through description of functional logic and existent reason of a column and its parts that "the square column k, having a base with the profile p r, is supposed to contain within itself another similar one, set

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[25] Ibid., 110.
[26] Kenneth Frampton, "Introduction: Reflections on the Scope of the Tectonic," in *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture* (Cambridge: MIT Press, 2001), 8.
[27] Ibid.

diagonally, and lift so far above the enclosing one…"[28]. To Ruskin, the concept of rationality means order in right place. By way of example, Ruskin examined details of a church in the Gothic style, examining structure, surface, windows and columns, and explained their violence of truth based on ornament. He uses the relation between *stone* and *traceries* to illustrate the truth of form and material through form and function of a garnishment on stone surface. Ruskin argued that when traceries reach to their truth under the worker's hands, no boundary exists between the detail and stone. At this time, stone does not hide itself and the art of stone appears in the form of the traceries. In addition, he explains using brick material, that a brick itself is artistic in its shape. It does not need painting anymore because it reveals its maker's qualities in its form.

Place concretization

In *Existence, Space and Architecture*, Christian Norberg-Schulz equates the tectonic with "existential space concretization"[29] of humans in the world. To human beings, existential space is a concept of understanding the psychological dimensions of a place. It reflects a human desire to improve their conditions in the process of interacting to nature. As a result of the interaction, architecture will ultimately present an unfinished image of wishes and dreams. He states to satisfy these wishes, human try to change their environment, and then it gives them feedback. Therefore, the relationship between human and environment is a two-way process.

Art of joining

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[28] John Ruskin, "The Lamp of Truth" in *The Seven Lamps of Architecture* (1849), New York: Farrar, Straus, 1961), 66.
[29] Christian Norberg-Schulz, "Architectural Space," in *Existence, Space and Architecture* (New York: Praeger Publishers, 1971), 37.

According to Frampton, the term tectonic denotes constructing or making of an artisanal or artistic product. The word tectonic has its origins in the Greek word *tekton,* initially signifying carpenter or builder. In the fifth century B.C this meaning evolves further, from denoting the specific and physical to a more generic notion of making, engaging in the idea of "*poesis*". Gradually, *tek*ton is taken to signify the master builders or "*architekton*". Eventually, the term refers to an aesthetic notion rather than technological type. Karl Otfried Muller defines the term, in his work *Handbook of the Archaeology of Art* (p.1830), as applying to a series of art forms, such as utensils, vases, dwellings and meeting places of men, which definitely form and develop because of their application and their conformity to sentiments and notions of art. In Adolf Heinrich Borbein's philological study (1982), tectonic turns into an aesthetic notion as following: "Tectonic becomes the art of joinings."Art" here is to be understood as encompassing *tekne,* and therefore indicates tectonic as assemblage not only of building parts but also of objects, indeed of artworks in a narrower sense."[30] Hence, tectonic implies a complete system attaching all the architectural parts into a single purposive whole and its environment. Tectonic with its true form, in its turn, modifies and articulates to the site. In this sense, true form means the *concretization of existential space*.

Dwellers as builders

True form and tectonic metaphor is also discussed by Martin Heidegger in *Poetry, Language, Thought,* in the essay *Building Dwelling Thinking*. He asserts that building is not means or end that leads to dwelling, but building itself is dwelling. "It is language tell

[30] Frampton, "Introduction," 4.

us about the nature of building and dwelling"[31]. He argued that man acts as though he were the shaper and master of language, while in fact language remains the master of man. And it is man that subverts the order of the relation between he and language that drives him into alienation. Among all aspects that make us human, language is the first, the highest, and everywhere. According to Heidegger, if we as *dwellers* listen to what language says in the word *bauen*[32]*-dwell,* signifying: to remain, to stay in a place, we can say here, "Building is really dwelling, dwelling being the manner in which mortals are on the earth, building as dwelling unfolds into the building that cultivates growing things and the building that erects buildings." [33] To Heidegger, truth of form, created by workers, exists in a work as art that opens an existence in the living world through its existence. He puts building in relation to all things on the ground that we call the earth, that the early Greeks called "*phusis*", that clears and illuminates that on which and in which man bases his dwelling. "Earth is that whence the arising brings back and shelters everything that arises without violation. In the things that arise, earth is present as the sheltering agent."[34]

The concept of the tectonic relates to the process of opening a world which at the same time sets the world back again on earth. To be a true architecture or true form means to set up an existential place. The form is added and fit to the gap of environment what are already there: men, animals, plants and things.

1.4. The foreseen organic form

[31] Martin Heidegger, "Building Dwelling Thinking" in Poetry, Language, Thought, Trans. and Int. Albert Hofstadter (New York: Harper & Row, 1871), 144.
[32] Ibid.
[33] Ibid., 146.
[34] Ibid., 149.

1.4.1. Form transformation

Organicism flows continuously in architectural history. In each of era, specific organic forms appear from simple to complex, with the universal idea of compatibility between the whole and its parts, based on the equilibrium of psychology and aesthetics. The concept of organicism as the growth of nature begins from the Organic Architecture stage. However, pure organic form depends on the individual styles, those who understand the power of site. They are considered as the geometrical and harmonious whole in which its parts are interwoven to express the growth spirit of nature. Geometrical elements are deformed together with architects' endeavors of integration to site. They are art works of human reflection on nature filtered through a cultural lens.

Other modern architectural movements reflect the growth spirit of nature through applying nature's principles, such as proportion, physical forces, symmetry, and composition. Yet often there is a focus on function and its growth, physical structures and economics, whereby the integration between form and its site becomes abstract, or even separated.

In the evolution of the concepts of organicism and organic architecture, organic forms have still not achieved the status of a fully-constituted object. It belongs to human's perception of nature and the role of the building in place in which the building is the witness or memory of space and time, and where the place attends to the form-making. The development of the concept of organicism continues to evolve in a reciprocal relation to the birth of its forms [Figure 20].

Figure 20. The transformation to enviro-organic form

1.4.2. The enviro-organic form integrating to the built environment

Following the organic flow, we can see that various concepts at each era of architecture contain different forms due to changes in human perception. These forms influence perception, and in turn give birth to new form. They result from nature's conditions and human demands with regard to function and meaning under aesthetic psychology. The process of looking for the unity of form, function and meaning is still going on, and never ending. It is important to now return to a study of nature's growth and form to understand key concepts to allow the concept of organicism to evolve further. In common with Darwinian evolution and the transformational morphology of D'Arcy Thompson, an enviro-organic form grounded on prior forms is proposed in response to current social and environmental needs. This form inherits from strong points of those previous organic forms and is influenced from its place as a part of that place that it grows from the earth. In that way, the form as the whole organic accumulates demands of function and meaning including the natural and rational, to become "genius loci" in its built environment.

Primitive form

Prior forms of organicism can be summarized in six types. In prehistory, the demands given by inhabitation or cultural and social forces are very minor. Organic forms include cave dwellings, primitive huts, tents, and selected monumental structures such as Dolmen and Stonehenge. The imitation of nature is totally dependent on nature and thus those forms called primitive form are maintained in geometrical patterns such as cone, hemisphere, cube, square, circle, etc.

Vernacular form

Vernacular form is the next phase of transformation of primitive form with higher needs

because of an increased social and cultural force. It is the form without the architect, that directly and simply expresses native culture, and that adapts to local climate. It is erected from the Earth by indigenous experiences. Usually, added elements of vernacular form adapt to the new demands to include high-pitched roofs, eaves, yards, gardens, and porches.

Rational-empirical form

With the development of the modern science of nature based on methodological skepticism, rational- empirical form results from human rational and empirical thinking begun by Descartes. It is pure geometrical form, or modern forms such as box and sphere, that constitute singular form or grouped form in architecture adaptable to nature by technology. Rational-empirical form appears as invasive to nature by its volume or mass.

High-tech form

Accordingly, high-tech form is created by singular and complex form that is deformed, such as bending or twisting, in order to satisfy human demands in the digital age. This form is adaptable to climate by use of high technology. It characterizes features invasive and communicative to nature by surfaces such as green screen and roof.

Organic form implies form of pure Organic Architecture. Its form language is the same as modern form but it is associated with traditional experiences of handcraft for the purpose of representation of space and time and integration to site, such as ornaments on surfaces, supplement of architectural elements: high-pitched roof, lanai, yard, eaves, and garden. This form adapts to climate by modern technology and yet retains more direct access to nature.

In an attempt to find equilibrium between nature and human forces, regional form combines vernacular, rational-empirical form, high tech, and organic form. It is impacted by native culture. And it lands on earth and responds to local climate by tradition and modern technology.

Enviro-organic form

Enviro-organic form results from the advantages of previous forms and integrates to its site with modern form including singular and complex form. The organic whole is organized following natural principles and its form is influenced by its natural environment. Ornament is no longer used as surface decoration, but integrated into form. This enviro-form responds to traditional experiences adaptable to nature and human culture such to minimize the invasion to the environment by modern technology. Its process is taken to be a “growing on earth”. The expression of enviro-organic form consists of form and structure. Because of human agency, enviro-organic architecture cannot literally grow as a natural form. However, the process of producing such form must be considered, because the final form is reflective of its process of coming into being. There is first an indefinite arrangement of spatial units grounded on site, which are in turn deformed by the forces present that include the cultural, material, environmental, structural, and psychological.

CHAPTER 2. FORM, FORCE, AND FUNCTION OF THE ENVIRO-ORGANIC FORM IN THE BUILT ENVIRONMENT

2.1. Human and natural agencies

2.1.1. Concepts of force

Physical and non-physical force

According to Thompson's understanding the term "force" in Newtonian language, force means the action of producing or changing motion, of preventing change of motion, or of maintaining rest. When dealing with concrete matter, force is energy that is present in the forms of matter, and that act on matter. Force causes the change in states of matter, such as changes of form, motions, and movements. In physics, force acts as a diagram of matter with magnitude and direction. Force also causes changes in growth or decay.

Function forces

In architecture, function is considered as one force on form. The force can be equated with dwelling force in a primitive stage. Based on man's perception of usefulness, force of function consists of utility force, gathering force, and *socio-cultural force*[35]. These forces are always influenced by natural forces, such as weather force and gravity force. In enviro-organic form, function forces also are impacted by environmental force. Under those forces, forms are deformed in three dimensions. The form-force relations are governed by the human psychological force of equilibrium in consideration of shape, proportion, comfort, utility, etc.

The problem of function and form officially appears in architecture in the 1900s and

[35] Amos Rapoport, "Socio-cultural Factors and House Form," in *House Form and Culture* (London: Prentice-Hall, 1969), 49.

function is held as the main force on form during this time. Consequently, separations of organicism, or the imitation of nature, in architectural design took place then. In around 1920, two variations of the form-function relationship are seen: “form after function” in mainstream Modern Architecture and “form from function” in Organic Architecture. In Modern Architecture, function is seen as principally utilitarian, whereas in Organic Architecture, function is seen as the integration to nature.

Environmental force

Environmental force impacts enviro-organic form. In the early 20th C, form is taken to be shaped by the forces of function, where function is typically a response to social needs. Forms then are derived, and they originate from the purpose of their existence, the dwelling force. Natural form, in contrast, is derived from natural forces as gravity and climatic force.

However, environmental force impacts architectural form via human action. People respond to environmental force and shape their dwellings to satisfy psychological, social and physiological needs. But these needs of humans are not simply in response to base function, but also to encode existential meaning. Form then expresses humanity’s relation to the environment. Environmental force therefore brings new meaning to architectural form because it impacts on the existential condition of humans dwelling on the earth.

Varied positions are seen historically regarding human relations to nature under environmental force. Some lines of thought are continuous, some are interrupted, some are later reconnected, or opened. Table 2 shows a listing of forces, their characteristics, and their influence on form.

	Human				Nature		
Feature	Psychological force of equilibrium				Equilibration		
Status		Functional force			Natural force		
Forces	Dwelling force	Gathering force	Utility force	Socio-cultural force	Weather force	Gravity force	Environmental force
Influence	Useful space	Structure of form	Maximum useful space	Shape and structure of form	Shape of envelope Composition	Framework Skeleton	Deformation Structure of composition
Meaning	Survival	Survival	Utilitarian	Social and cultural	Natural	Natural	Existential
Direction	Horizontal	Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical Horizontal	Vertical	Vertical Horizontal
Magnitude	Temporary	Temporary	Permanent	Permanent	Permanent	Permanent	Permanent

Table 2. Human and nature forces

2.1.2. Force and building behavior

Fundamental confederation

For the most part, the unity of form and function under non-physical forces can be seen at the beginning of time in both natural and human worlds. With only need of dwelling, primitive man makes his dwelling with a very simple shape because of the need to provide shelter using available tools, techniques, and materials. Functional force and environmental force can be seen as separate, but ultimately act together at the same time. Environmental force (such as rain, harsh sun), causes the human to form sheltering roofs. At the same time the social needs of inhabitation cause an arrangement of space that may deform the shape of the roof and enclosure. The action is very similar to nature's builders, such as birds, ants, or bees. Their nest shapes are formed by balancing force, form, and function from their motive of existence under certain circumstances. Under forces in different directions, dwelling forms evolve to the most stable geometrical forms and structures, such as the honeycomb of the bee, the veronoi structure of the leafcutter ant's nest, and the woven structure of a bird's nest [Figure 21].

Figure 21. Singular forms under animal function force and nature force

Animals select geometrically regular and optimized forms which lead to minimal use of resources including labor, material, and time. In a similar way, humans endeavor to optimize resources. Figure 22 shows the typical human dwellings resulting from the intersection of natural force and human dwelling force.

Figure 22. Form transformation under human and nature force

Auto-adjusted unification

While there are similarities between how humans and animals build, human dwellings are more complex given the various social, functional, and other factors that influence their form. Force, form, and function are united. The typical living pattern of humans is for a family to share an individual house, and houses are aggregated to form villages or cities. The aggregation can be said to result from the social needs of humans, and this may be considered a gathering force. In the process of establishing society, socio-cultural force appears, and along with it, the related aspects of myth, religion, and the search for existential meaning. As a result, the simple and primitive forms are transformed and enriched from the influence of the socio-cultural force [Figure 23].

Figure 23. Formal adjustment under function as main forces and natural forces[36]

The dwelling forms that humans create serve to protect them from harsh effects of nature and satisfy their social and functional demands. Humans have of course developed a variety of forms to best meet their unique circumstances [Figure 24]. Animals' forms, change slowly over time following evolutionary processes. Natural forms are formed

[36] Victor Olgyay, "Environment and Building Form," in *Design with Climate: Bioclimatic Approach to Architectural Regionalism*, cooper. Aladar Olyay (New Jersey: Princeton, 1952), 62.

from adaptation and fitness to their role in a specific ecosystem, such as leaf forms in different climate zones [Figure 25]. Functional force, gathering force, socio-cultural force, weather force, and environmental force, are present in various types of architecture, such as vernacular, critical regionalism, and modern architecture, though their degrees of presence are different in each case because of man's varied demands.

Figure 24. Formal solutions adapting to weather force[37]

Figure 25. Adaptive morphology of plant in various environments[38]

2.1.3. Forces significance on form

Division and meaning

Organicism includes the concept of unity of form, function and force. However, because the majority of buildings do not respond to the environmental force, they lack in meaning. Because such buildings do not relate in any specific way to their site conditions, they can be easily placed in any number of sites. The Fallingwater house designed by Frank Lloyd Wright is one sample where the functional force is incorporated, and where environment force is incorporated only in part [Figure 26]. It does not integrate to its surroundings, though it is designed as if it is rooted into the hillside with its cantilevered flat roofs.

Figure 26. Accessing to nature, Falling Water House, 1935-1938, designed by Frank L. Wright

The exploitation and application of functional force to design lead to various forms in architecture. Depending on the purpose of the function, its form is directed to producing a useful thing, such as an art work, or a natural appearing object. In such a case the

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[37] Victor Olgyay, "Environment and Building Form,"85.
[38] Ibid., 91.

meaning of form relies on function. For instance, if in designing a church the focus is only on creating a place where people pray, the church will be a box with the maximum space along with furniture inside. But if the design includes a fuller understanding of the spiritual dimension of the activity, the architect may introduce connections with nature, such as light and dark, water and rain, trees and forests, hills and mountains, and fog and clouds. So connected, the church will be an artwork because it produces meaning via the connection of spirituality and nature. Humans produce the socio-cultural force which then impacts form. Aspects of this idea are evidenced in the Church on the Water designed and built in 1985-1988, Japan, by architect Tadao Ando [Figure 27].

Figure 27. Meaning of function, Church On The Water, Hokaido, Japan, 1985-1988

The church is a box with one wall replaced by a large sliding glass wall that allows a view to the pond outside. The pond is stepped to produce noise from the falling of water. The Christian cross is placed in the pond. The design symbolizes Christ's Passion, and peace that may come to the world. Another example is the church of Notre Dame du Haut in Ronchamp, completed 1954 designed by Le Corbusier. Different from Ando's approach, it shows a heavier influence of symbolism. The building is placed on the site and formed with allusions of a priest's hat or clasped praying hands [Figure 28].

Figure 28. Symbolic meaning, Notre Dame in Ronchamp, 1954, designed by Le Corbusier

Significance of assemblage

The meaning of form from force and function is also implied by Heidegger in his book *Poetry, Language, Thought* in the Chapter *Building Dwelling Thinking.* Heidegger poses two questions: "What is it to dwell?", and, "How does building belong to dwelling?" We can attain to dwelling because of building, and in turn, building takes dwelling as its goal.

Thus, "building is in itself already to dwell."[39] Therefore, the form of building results from all of human activities such to reach the purpose of dwelling. Animals build similarly to man in order to provide for dwelling. However, because humans dwell between heaven and earth, they stay before the divinities, a 'belonging to men's being with one other'[40]. Thus, "earth and sky", "divinities and mortals"[41] belong together as one in a primal oneness. For this reason, functional force appears first but it cannot exist alone but must coexist together with the others as gathering force, cultural force, weather force, and environmental force.

How many forces exist in the making architectural form? The question seemingly has not been answered yet because of the change and evolution of human cognition. Recent changes in the world, such as globalization, climate change, and population growth have further changed the human condition. As a result, humans adapt form to match the new circumstances.

Many types of modern architecture have privileged functional force which has led to fragmentation of the unity of a wider set of forces. The fundamental unity of forces divided a *flowing movement* of thinking and design. By separating out the forces, the sense of unity was lost. By necessity, humans have limits, and must reduce complex problems to manageable scales. According to David Bohm, humans, "lost awareness of what he was doing and extended the process of division beyond the limits within which it works properly."[42]

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[39] Heidegger, "Poetry, Language, Thought," 144.
[40] Ibid., 147.
[41] Ibid.
[42] David Bohm, "Fragmentation and Wholeness," in *Wholeness and the Implicate Order* (New York:

This separation is also criticized by Heidegger in *Building Dwelling Thinking* when dwelling is separated from building and dwelling and buildings are compared to "ends and means."[43] When building is considered as means, bridges and hangars, stadiums and power stations, and even cars and factories can be called architecture because they have the function of dwelling. For Heidegger, architecture "gathers to itself in its own way earth and sky, divinities and mortals."[44] In which earth means "under the sky" and plays a role as *serving bearer* who takes charge of "blossoming and fruiting, spreading out in rock and water, and rising up into plant and animal."[45] The sky is the sun vaulting path of day and night, the changing moon full and crescent, the twinkling of stars, the changes of year's seasons, "the gloom and glow of night, the clemency and inclemency of the weather, the drifting clouds and blue depth of the ether."[46] The Divinities are "*the beckoning messenger"* of the sky. By the holy sway, the divinities appear in his presence or "*withdraw into his concealment*." Therefore, building means dwelling as the manner in which humans exist on the earth.

Building means cultivating growing things as erecting buildings. Accordingly, enviro-organic form presents the meaningful place where functional force, weather force, gathering force, cultural force, and environmental force are assembled. As Thompson said, the form of an object is a diagram of forces in equilibrium.

2.2. The appearance of nature's forces

2.2.1. Synthesis of space and framework

Routledge, 2002), 3.
[43] Heidegger, "Poetry, Language, Thought," 144.
[44] Ibid., 151.
[45] Ibid., 147.
[46] Ibid.

Gravity force impact

In physics, there are four fundamental forces: the gravity force, the electromagnetism force, the strong nuclear force, and the weak nuclear force. These forces became present in the natural world after the Big Bang, which theorized the formation of the universe. The gravity force is the cause of a leaf falling to the earth. The electromagnetism force can help to create artificial light in houses and flashes of lighting in the sky. The strong nuclear force causes decay in atoms and permits a nuclear power plant to provide electricity to buildings. The weak nuclear force allows the formation of molecules to produce animals, plants, houses, and lands, etc. For the most part, the gravity force acts on the macro scale while the other forces act on the micro scale. The gravity force links nature and architecture, in particular enviro-organic form in its structural system.

Integration of form and structure

Architectural form is commonly understood to be limited to the idea of enveloping form / shape, which is often separated from structural form. Ultimately however the architectural form must work in conjunction with the structural form. For example, a building using a frame structure including posts and beams is described as skeleton for architectural form. Under gravity force, the skeleton works together with floors and walls that may provide resistance to lateral loads. They support beams and columns to simultaneously sustain axial loads, shear loads, moments from dead loads (gravity: self-weight) and live loads (wind, snow, seismic, people and equipment, etc.). Although playing an important role in determining architectural form, structural form is often hidden behind other layers of construction, and is not given a unified expression. Another position can be taken, and architectural and structural form can be integrated, and the

structure can influence the architectural form. In other words, structure is taken to be the *form-giver*[47]. The concept of structure in architecture differs from that seen in nature. Structural form and enveloping form are united in natural forms. Depending on the scale and impact of gravity, the structural form is divided into primary system and sub-systems, and work together.

There is a difference between natural form and architectural form in that natural form optimizes the enveloping system, some being a non-structural enveloping system. This strategy leads to saving material, while facilitating energy transfer and offering multi-functionality. Hence, the structural system of enviro-organic form is integrated with the architectural form; they co-exist and work in a symbiotic relation. Here enviro-organic form becomes true form as natural form. Its form is not simply a mechanical response to forces but also for use, such as spatial partitioning, or as a symbol to produce meaning. If the structural form is changed, the architectural form will respond in kind. This is confirmed by Viollet-le-Duc, 'Impose on me a structural system, and I will naturally find you the forms which should result from it. But if you change the structure, I shall be obliged to change the forms.'[48] Pier Luigi Nervi reaffirms Viollet-le-Duc's belief in structure, '… form must be the necessary result, and not the initial basis of structure.'[49] In the context of high rise and long span construction, Glasser supported Pier Luigi Nervi's view, 'as in the case of arenas, auditoriums, and stadiums – it is clear that a conceptual

[47] Andrew W. Charleson, "Relationships between architectural and structural form," in *Structure as Architecture* (London: Elsevier, 2005), 22.
[48] Ibid.
[49] Ibid.

design without a rigorous and well-integrated structural framework would be specious.'[50]

2.2.2. Enviro-organic form's structure

Shell structure

In *Structure as Architecture,* Andrew Charleson selected seven structural systems to be considered as the basis of architectural and structural form. In those cases, structure determines architectural form and plays the function as the building envelope.

The first structural type is shell structure or surface structure in which the structural system is closely paired with architectural form. Shell structures resist external loads and internal forces with minimal thickness. Shells are typically shaped with three dimensional doubly-curved geometry and resist loads through membrane stress. Shell structures are commonly made from reinforced concrete, having smoothly curved surfaces inside and outside. For example, the shell of the Laboratory and research facility for the Gips Union SA, in 1968, by Isler, the shell springs out from the foundation and curves continuously to envelop the interior space. At the Palazzetto dello Sport, Rome, by Nervi, the shell defines the roof form, functioning simultaneously as structure and enclosure. Its interior surfaces are ribbed to stiffen the shell while allowing openings for the admittance of daylight. The Eden Project, Cornwall, by Nicholas Grimshaw, is an example of a shell structure constructed from linear steel elements. The hexagon, a geometrical pattern found in many natural structures, is used for the module of these shells. A secondary inner layer of tension rods is added to support the outer primary hexagonal steel structure due to the long 124m span. The shells, "achieving rational, economic and transparent

[50] Ibid.

construction"[51], illustrate the synthesis of architectural and structural form that is extremely close to forms found in nature [Figure 29].

Figure 29. Shell form

Fabric Structure

The second structural type is fabric structure, or membrane structure. Similar to shell structures, it resists loads by arranging three dimensional membrane curvatures taking tension force. Initially it resists self-weight and other loads by its thickness and strength that match the expected loads, and its surfaces must be stretched taut to sustain high wind loads. However, fabric structures require periodic compression members to help support the membrane. At the Stellingen Ice Skating Rink at Velodrome, Hamburg, Germany, by Silcher, &Werner, the fabric is supported by four masts projecting through it, and tension cables are arranged to support compression struts [Figure 30].

Figure 30. Fabric form

Catenary structure

The third structural type is catenary structure. This type is similar to fabric structures in that loads are resisted through tension. It can be imagined that the structure is like a draped cable that spans between two high points. The centenary form is usually applied to long span roofs. The roof self-weight exceeds the wind suction or uplift pressures. Reinforced concrete is often used as the catenary form material. There are two common approaches used for roof catenaries: for lighter catenaries, a ballast or a separate tie-down system is used to support; for long-span catenaries, tension members are exposed within or outside the building envelope. The Portuguese Pavilion canopy, Lisbon designed by

[51] Charleson, "Relationships," 25.

Alvaro Siza, 1998, or the Dulles International Airport Terminal, Washington, D.C., by Eero Saarinen, 1958, and Hall 26 of the Trade Fair, Hanover, by Thomas Herzog and Partner, 1996, are examples of these two approaches [Figure 31].

Figure 31. Cantenary form

Rib structure

Rib structure is another structural type that closely defines architectural form. However, the rib structure is often separated from the enveloping system. Rib structures are commonly found in nature. In architecture applications, the ribs cantilever from their foundations or are connected with pins at their bases. When inclined from the vertical or curved in elevation, ribs are propped up by other ribs to attain equilibrium. Rib structure is applied to single forms instead multi-story structure. For example, at Licorne Soccer stadium, Amiens, France, designed by Ateleir d'Architecture Chaix & Morel associates, built in1999, the ribs are propped near to the bases with an elegantly curved and tapered profile, and they provide spectators a sense of enclosure. In the Reichstag cupola, Berlin, Germany, designed by Norman Foster and Paul Wallot, completed in1999, ribs are connected by a crowning compression ring and propped up by the other ribs within the dome surface to resist gravity and lateral forces [Figure 32].

Figure 32. Rib form

Arches

The unity between architectural form and structural form is also evident in arch structures. At the Paul Klee Museum, Berne, Switzerland, by Renzo Piano, 2005, conventional arches are regularly spaced and attached to their foundations. The building structure is made from repeated arches to respond to its site shape and surroundings. At

the Great Glasshouse Botanic Garden, Carmartheshire, by Samuel Pepys Cockerell, 1999, arches are used in a dome configuration. The building form articulates to its surrounding landscape. Its structure includes two layers of arches interwoven like curved web net. The arched structural form can be applied for small and large spaces [Figure 33].

Figure 33. Arches form

Frame structure

Frame structure is considered as the result of the relationship between orthogonal skeletal structural frameworks and rectilinear forms. It can be called another case of rib structure but its skeleton function is different because it is used for single or multi-story construction. Often frames determine room width and depth as well as circulation area. Orthogonal beam-column frameworks mostly integrate into architectural forms. The structure is prevalent in architecture, such as in La Grande Arche, Paris, designed by Johan Otto van Speckelsen, completes in 1989 and in San Cartaldo Cemetery Columbarium, Modena, Italy, designed by Aldo Rossi, in 1984 [Figure 34].

Figure 34. Frame form

Wall structure

Wall structure is another case where architectural and structural form may be integrated, because walls dominate the façade and define interior spaces. The walls may take loads, and thus replace beams and columns. Walls can be combined with frames to define architectural form because their flexible sizes and locations within building. Sometimes walls are added to the frame structure or replace some columns and beams to make the building skeleton stronger. In this case, Tama Art University Library, Tokyo, Japan, built 2007, and the International Museum of the Baroque, Puebla, Mexico, 2016, designed by

Toyo Ito are typical examples [Figure 35].

Figure 35. Wall form

Tree structure

The appearance of environmental force causes new structural form to be created. With the participation of the environmental force, tree structure or mushroom structure is added as another structural type. It too may be integrated with architectural form. Mushroom structures resist loads by cantilevered slabs often having shell form which transfer forces through columns into the foundations. Depending on the architectural typology, the structural form may be combined other structural types to articulate a desired relation between human force and natural force as gravity [Figure 36]. The integration of architectural and structural form shows explicit links to the tradition of organicism as the imitation of nature: "from whole to part" that flows continuously in history of architecture. In prefabricated construction, for example, the assemblage of pre-formed units is used to constitute a whole. The understanding of whole-to-part relationships is seen in human works and nature.

Figure 36. Tree form

2.3. Environmental force in the built environment

The environmental force comes from nature and belongs to human need to be part of nature, as humans live in and interact within nature. Nature's images influence human's forms and their aesthetic. Thus, principles of beauty as well as of forces are imprinted on human forms consciously or unconsciously. However, force is rarely mentioned in connection with the other forces, such as functional force, gathering force, and weather force, whenever human affirm their position in nature via architecture. Different from the

others, environmental force is the impact on form issuing from the natural context. The environmental force helps architectural form to integrate to the natural environment. It also brings historical meaning to the form by tracing primitive memories of the landscape. Thus, environmental force produces aesthetic and semiotic conditions of architectural form. This aesthetic may relate more to human experience of the natural landscape rather than specific human action.

In ancient times, humans formed their houses according living habits, and the forms produced were often quite simple. However, the forms linked to nature in a variety of ways, through, for example, the use of natural materials, and for the need to mediate the effects of weather. Gradually, human perception is enhanced by understanding of nature through cultural and social development. New forms of architecture were produced to meet the emerging requirements of use and enjoyment. Instead of a direct and simple relationship to nature, the relationships are often hidden or abstracted via use of geometric or compositional rules.

Nature is beautiful because of its unity in diversity. To achieve unity, nature follows symmetrical principles, and to reach diversity, symmetrical principles are broken. In the process nature maintains equilibrium. Humans in turn endeavor to find a balanced or symmetrical relationship to nature. Humans have a tendency to base form on geometry as this is already a natural tendency in their subconscious. According to Plato, *the world is just image of perception*. Human memory holds a dynamic space including natural elements: tree, water, sky, terrain, architecture ... and people. Humans have developed geometry and mathematics as means to understand the variety of natural form. Spontaneously, these means are brought to process of making architectural form. In other

words, environmental force embodies natural structure and its geometry in both human memory and architecture. Benoit MandelBrot, developed *Fractal* geometry, which describes complex forms that cannot be easily described by Euclidean geometry. Such forms may resonate in human memory, and evoke emotions. The feeling of beauty may in part result in perceived forms linking to past memories.

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To conclude, environmental force impacts on architectural form. It leads to the different ways architecture responds to nature and how a unity of architecture and structural form responds to gravity force. Enviro-organic form under the influence of environmental force satisfies human demand of aesthetics, relating specifics of a site with human

perception and individual and collective memory.

2.3.1. Transformative tendency

A living organism presents equilibrium as symmetry in which is a complex field of internal and external forces and micro and macro forces. But nature delights in transformation for diversity and adaptation. Thus, processes of deformation or reconstruction result from the shifting influence of a constellation of forces. Similar to nature, the growth and evolution of architectural form via human evolution direct to transformation under impact of human and natural forces or, according to Aristotle's words, motive or causal ends (material, effective, form, and purpose). The change of form can be visible in periods of architecture that lies in the process of growth, construction, and function. The comparison between nature and architecture shows the similarity of growth of form following time and subject to simultaneous forces. Humans are unable to make forms as good as nature because humans possess only a limited understanding of nature. However, to some extent, enviro-organic form can take on the characteristic of natural form through the idea of "a whole purposive to parts". The concept of a purposive whole leads to a selection of an initial functional form as a pattern or *archetype* for the process of growth that may then be transformed to match to its environment.

2.3.2. The morphological growth

Organic unit

In *On Growth and Form*, D'Arcy Thompson asserts the interrelations of growth and form, called "Morphology", are not merely an increase in size but also a transformation. This concept is different to Aristotle's view that the world is determined and formed by

fundamental elements such as earth, water, fire, and air as basic geometries. For Thompson, the process of growth is organic, but the starting point of growth is inorganic. Larger forms can be products of the accumulation of smaller forms. The laws of growth can apply to the individual organism and to the species as a whole. In other words, the growth of an individual can be generalized to all of the individuals within a species or a group of species. The idea is similar to Benoit MandelBrot's natural structure that is based on an initial geometric pattern that undergoes a process of self-similarity and iteration. Thompson's laws of growth are suitable to all biological growth but expressed in particular ways that depend on the environment and form of organisms. This hypothesis allows us to generalize about the process of morphological growth of enviro-organic form within certain types of form based on observations of a few related forms.

Organic tool

Humans have devised various methods to understand morphological transformations as they play out in time. The rectilinear grid is one method, which is a useful tool for mapping. According to Thompson, the transformation in growth can be traced on a Cartesian coordinate grid. Various types of transformation result from bending, tilting, or deforming the grid. The deformation, based on the grid, is considered as representative of significant alterations in various forces and rates and growth throughout the developmental process of an organism. For example, he gives the transformation of circle to ellipse, or of bones to different shapes and scales, attached to 2D grid system, with the descriptions of mathematic equations. Several types of deformation are seen below [Figure 37].

Figure 37. Biological transformation through environmental impacts[52]

The figures show the correlation of the whole to its parts under the influence of force. The coordinate grid is a frame to account for the transformation and a means to predict subsequent formal development. Hence, enviro-organic form is provided a novel way to easily visualize the morphological differences or diversity between shapes in the built environment.

An architectural work may then be influenced in part by the form present at its site. Selection of a form depends on human functional requirements. Elements of form are homogeneous and structure of form follow principles of the whole, branching, and repetition.

2.4. Geometrizing the forced whole

Geometry is a branch of mathematics that is an effective instrument in design and construction which has served builders since ancient times. Geometry allows full form to be accounted for via an abstraction that can then be transformed and deformed. D'Arcy Thompson states that biological shapes of plants and animals are only not influenced by evolution. Form engages mathematics, while growth is a physical issue.

The earliest civilizations recognized the beauty of nature and understood it through fundamental geometric shapes and harmonic proportions. The circle, ellipse, triangle, and rectangle, and the Golden Section or Fibonacci series, are taken in many periods to be the primary generators of architectural form and of organic growth. Geometry cannot define all things, but can describe them under the influence of force and account for their

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[52] D'Acy W. Thompson, "The Comparison of Related Forms," in *On Growth and Form* (Cambridge: University Press, 1942), 1063-1064.

patterns of growth and transformation. Benoit Mandelbrot's Fractal geometry begins to influence architectural design in the 1970s. However, the application of fractal geometry was limited to the structure of composition, and not to trace force-form transformations. For example, Peter Eisenman uses fractal geometry in his design of the Wexner Center at Ohio State University. At the same time, Charles Jencks introduced catastrophe theory into architectural design, and Greg Lynn applied algorithms to produce complex forms generated from doubly-curved and folded planes.

The impact of forces on form leads to an initial selection of primary geometrical form, such as box, cone, cylinder, or sphere for the whole. These forms in turn may be transformed via the synthesis of functional force and psychological force. Sullivan, in his essay *Inspiration* (1986), asserts that the fusion of geometric and organic shape is a natural principle of design. Refined plant motifs with simple squares, cut by diagonals and orthogonal axes are used in his designs. He recognizes curvilinear principles (feminine principles) in floral and other organic shapes, and these forms being reformed in primary geometric linear shapes (masculine principles). To Wright, building itself is organic form as a whole and not only its elements, as shown for example in the helicoid of Guggenheim Museum. This approach is seen also in Gaudi's work, such as the hyperbolic hyperboloid pillars in the Sagrada Familia. In his early career Le Corbusier, composed boxy, functional, and sterile forms, but later began to explore organic form as seen in his Chapel Notre Dame du Haut, where the walls, the roof, and the floor slope in free curvilinear shapes. Buckminster Fuller follows the principle of making the whole from a repetition of cells. He uses radiolarians as a source of design permutations, and geometry as a tool for translation in architecture. His invention of the Geodesic Dome is

comprised of a whole spherical or semi-spherical structure, consisting of a grid of triangular parts.

In conclusion, geometrical organic form as a whole should be related to its natural surroundings, and to man. The horizontal direction has been used to stand for the influence by the growth on earth, and the vertical for man's response to his own needs in relation to nature. Form transformation depends on the magnitude of forces as well as human cognition set in a temporal sequence [Figure 38].

Figure 38. Nature and human forces, form, and function

CHAPTER 3. ANALYSIS OF ORGANIC FORM IN ARCHITECTURE AND NATURE

3.1. Architectural and natural cells of form

3.1.1. Organic archetype

Organicism contains archetypes influencing architectural shape and structure inflected by "the richest possible stratification" of human experiences over time. It is based on a structural and symbolic interpretation of nature that is in turn used to establish methods, laws, and principles. These come into being through human perception, language, and thought in relation to each other and with nature. Carl Jung describes his theory of the collective unconscious, "by nature archetypes are strongly rooted in matter and often involve all five of our senses even if they are immaterial." [53] Human cognition of the whole, proportion, arrangement, order, and integration of physical and psychical life is formed from organic archetypes. They serve as the underlying psychological force which calls upon geometry and composition for purposes of expression in physical form.

In fact, primitive organicism in architecture expresses as partial imitation and does not relate to the outward appearance of natural objects. This action is the attempt to assimilate the objects' transcending elements, their possible use in satisfying human's needs and desires as well as its capacity for symbolism. The beginning type of natural imitation, characterizing architecture, thus can be defined as *symbolic imitation* that includes analogy and mimicry of nature's laws, forms, and processes. To put it differently, through archetypes of organic forms, human render their natural experiences

[53] Paolo Portoghesi, "Nature and Architecture," in *Nature and Architecture* (Italy: Skira, 2000), 11.

and reproduce nature's form and structure in a distinct way. In such a way, organicism appears as "the constructed object as being both near and far, traceable and lost."[54]

According to Paolo Portoghesi's understanding from Fischer Barnicol's research and Schneider's studies, architecture is the fruit of man's organizing mind that relates to the limitless manifestation of the mind in nature, and the organic symbol is the simplest and most profound instrument used to express a given reality in a different medium. Through a symbol, a transcendent force which is literally invisible and intangible is revealed in a material object, such as the house origins lying in the tree, the cave, and the nest of birds, but also relating to the archetype of prenatal life in the womb. So, when building a house, primitive man does not intend to imitate forms but to symbolize living conditions that were either imaginary of gleaned directly from his own experiences. He grafts his building onto nature in a manner such to continue a process of creating the world.

In the same fashion, Gaston Bachelard articulates the notion of the organic archetype of collective memory, such as peasant huts and hermit shelters. In *The Poetics of Space (1964)* he suggests that humans are influenced consciously and unconsciously by primordial existential conditions of inhabitation. Humans need houses as archetypal forms such to dream and imagine, connecting thereby to the full history of human existence. For Bachelard, a house transcends geometrical space.

The enclosure of the house is in itself an archetype that serves as the portal to the imagination. The simplest containers he mentioned are "*cottage chrysalis*" from which there is a flow of intimacy, as presented in nooks and crannies, gardens, and the forest.

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[54] Portoghesi, "Nature and Architecture," 14.

Junichiro Tanizaki, in his book, *In Praise of Shadows*, discusses the role of archetype in human dwelling. Because the basic human need is to inhabit, archetypes form around daily living activities and the spaces that contain them. They are human requirements of function and memory. The notion of the room or cell archetype is evidenced in Sullivan's, Wright's, Gaudi's, and Le Corbusier's work. Sullivan's cell archetype is expressed in decorative motifs; Gaudi's is focused on structural forms; Wright arranges rooms as cells in an organic whole; and, Le Corbusier presents singular prismatic volumes.

3.1.2. The archetype samples

The human body

The archetype of the human body is perhaps the first to emerge in human history, and one in which man seeks to find his connection to nature. The body is used as guide to the laws of architectural composition and proportion of elements. The principles lead to theories of unity in multiplicity, uniqueness, and identity of a whole made up of separate parts. The human body is taken as God's most perfect creation, and its form serves as the model for man's creations [Figure 39]. In modern architecture, the archetype is usually applied to architecture through interpretations, such as the Vitruvian man, and Le Corbusier's *Le Modulor*.

Figure 39. Human body archetype

The skeleton

The skeleton archetype sprung out of the human understanding of the load bearing structure of the body. Under gravity force and weather force, the skeleton supports the body and makes its form possible. The understanding of the skeleton leads to the concept

of the dichotomy between the load bearing frame and the skin. The skeleton archetype is embedded in buildings, and takes its origin from primitive huts made of branches covered with animal skins or thatch. Materially, this has meaning for not only wooden frames but also those made iron and reinforced concrete. In masonry buildings, the archetype of the skeleton may not be present, owing to the load bearing capacity of the wall. However, some structures, such as seen in gothic architecture, the frame reemerges as slender columns, ribs, and buttresses. Alberti's concept of organism is very similar to the static behavior of an organism in which the skeleton, muscles, and nerves act as system in cooperation with its growth [Figure 40].

Figure 40. Skeleton Archetype

The womb or nest

The womb archetype symbolizes the protective initial enclosure for the human as fetus. It becomes the conscious or unconscious model for the construction of human dwellings. The house is a manifestation of the archetype offering safe shelter. Womb-like forms are found in nature, such as caves and other landforms, which were often considered as sacred. The oval shapes of these natural archetypes recall fertility, and the primacy of Mother Earth (yin) and her beauty as a space of emptiness [Figure 41].

Figure 41. Womb and nest archetype

Verticality

The archetype of verticality connotes the holy virility (yang) that it is symbolized by menhir, obelisk, or phallic symbol in ancient architecture, or the skyscrapers in modern architecture. It also relates to the sacred characteristics of mountains, such as permanence and eternality, as a reference to cosmos [Figure 42].

Figure 42. The verticality archetype

Animals

Human admiration of nature includes animals, and the animal archetype manifests in the symbolism of animal bodies. Architecture uses symbolic imitation to communicate and confirm a collective idea, analogous to the creation of myths. The features of animal bodies, such as the wing, the claw, the beak, the horn, and the skin, are transferred in architectural form for aesthetic and functional purposes [Figure 43].

Figure 43. Animal archetype

The tree and branch

The tree archetype symbolizes the verticality of the microcosm as man due to its similarity of genesis and growth. The tree connects to the solidity of a building through its trunk as column, and the sheltering leaf canopy as roof. Its branches inform man about the form potential of expansion and multiplication. The order of trunk, branch, leaflets, leaves, rachis and venation are translated in architecture in the hierarchical orders of major and minor parts [Figure 44].

Figure 44. Tree archetype

The inflorescence

The inflorescence archetype offers for architecture, such as city, room layout, membrane structure, or decoration, a reproductive system in which flowers are arranged along a vertical axis as rachis or peduncle. The archetype is another repeated image in a lower level of the tree archetype. It attracts humans due to the various shapes and colors brought about through principles of irradiation, subdivision of overlapping layers, and developing forms [Figure 45].

Figure 45. Inflorescence archetype

The rock and crystal

The rock and crystal archetype appears when primitive humans used stone tools for rock building construction and when observing the fractured surface of mountains. Rock crystal forms influenced architecture as a model having the organic principles of complexity, regularity, rhythmic repetition, order, clarity, creation, and evolution [Figure 46].

Figure 46. Rock and Crystal archetype

3.1.3. The organic resemblance

Analogy

The organic archetypes mentioned above inform architecture principles as *analogy* and *homology*. The former is grounded on the harmony of function, and the latter based on the concordance of structure. Like echoes, the analogy of archetypes creates different repetitions, a resemblance that evokes the specific traits of family members having simultaneously common features. It also shows the primordial and universal logic behind all living forms. The logic of analogy comes from a force which is simultaneously logical and psychological. It creates order and equilibrium. Portoghesi cites Rene Alleau who states, 'analogy intervenes as an exploratory and unifying process capable of disclosing the general perspectives and harmonic or regulatory relations which logic of identity alone permits neither to be perceived nor identified.'[55]

Homology

Homology leads to the homogeneousness of shapes and their corollary by self-similarity.

[55] Portoghesi, "*Nature and Architecture*," 15.

D'Arcy Thompson offers an analysis of the growth of a cell through transformation and deformation. Similarly, A. Lima-de-Faria states that evolution is a physical and chemical phenomenon caused by a tendency towards self-assembly including *dichotomy* and *ramification* that present in elementary particles as well as in atoms and molecules.

Manifestation

Nature's self- similarity, understood in the concepts of analogy, homology, dichotomy, and ramification are placed under the heading of symmetry, Symmetry is found in nature's deep structures discovered by Benoit Mandelbrot's and illustrated in his Mandelbrot set (1975) which describes natural phenomena in different scales. Surprisingly, fractal principles are present in architecture though they are seldom mentioned in reference with architectural design. Nature's structures are imitated with repeated geometrical patterns using *self-similar* principles. The patterns may contain point, line, plane or solid shapes. The geometric units may maintain or transform similar forms. To articulate natural objects, random factors are added to the process of self-similar repetition.

Natural symmetries in architecture are expressed via mimicry and metaphor. The dynamic growth of nature is expressed by breaking symmetry. The laws of symmetrical conservation and transformation are governed by psychological force and expressed in shape, scale, direction, and weight proportion.

There are three types of symmetries in the natural world: bilateral symmetry, rotational symmetry, translational symmetry, as well as combinations of these types. [Figure 47]. Bilateral symmetry is perhaps most common, and is described as form having identical features present on either side of a central line or plane. Rotational symmetry is based on

copying similar forms and rotating them about a common center. Rotational and bilateral symmetry are sometimes combined, as seen in flower forms. Translational symmetry is understood as the simple linear repetition of an element. It is the basic symmetry of the mineral world and it is common in architectural design and primitive construction.

Figure 47. Symmetrical manifestation in nature and architecture

3.2. Architectural form as geometrical composition

3.2.1. Notions of composition

Distribution

The concept of "Distribution" came from French artists in the 18th C and was used to denote the arrangement or order convenient and elegant for life. This concept was used to relate the inside and the outside of a building. The elements of the order could be entrances, courts, rooms and gardens. The distribution of a building was separated in two divisions. The first was concerned with exterior appearance and helped to 'determine the layout of the "avant-corps", the pavilions, the "arrière-corps" and the "corps intermediaries" that bring a certain movement to the ordonnance of the facades.' The second related to, 'whose purpose is the division of rooms constituting the interior of the apartments.'[56] According to Jacques Lucan, exterior appearance is focused on decoration and beauty, while interior division is concerned with functionality and convenience. Jacques-Francois Blondel interpreted the Vitruvian triad as: solidity = construction, commodity = distribution, and beauty = decoration. The idea of distribution refers to "symmetrization" of each individual room. Blondel said of connecting rooms, "we

[56] Jacques Lucan. "Distribution, Disposition, Composition," in *Composition, Non – Composition: architecture and theory in the nineteenth and twentieth century* (Italy: EPFL Press), 11

broaden the respective regularity of bodies set up in opposition to each other."[57] Hence, a convenient apartment would often be based on a plan which structures rooms of varied but regular geometrical figures about axes of a great complexity. Julien Guadet wrote the introduction to Blondel's *L'Architecture Francaise*, where he emphasized that distribution should be the primary objective of the architect, while the plan is the first object of his attention. He referred to rooms in a house as "elements in the composition", connected by circulation, serving the notion of distribution.

Disposition

Disposition, "assigns to each thing its place and its use' and its meaning is set up in location, needs, uses, character sought, etc. It implies to 'the division, order and arrangement of the rooms that make up interior of an edifice."[58] Jean Nicolas Louis Durand stated that distribution is the art of composing private buildings and disposition the art of composing public buildings. The distinction of distribution and disposition relates to composing different parts of a building intended for habitation. In the middle of 19th C, Léon Reynaud determined that distribution should not be confused with disposition. The former relates to utility in the sense of commodity and usage, and the later involves satisfying the needs of utility '… and pertains to forms, dimensions, the overall economy, and the intended effect. The point of a given distribution is to be good; a disposition's is to be both good and beautiful.' From Durand to Guadet, a shift occurred between definitions of distribution and disposition. Guadet offered a conclusion

[57] Ibid.,13
[58] Ibid.,19

that,"disposition is what we call composition."[59]

Composition

In architecture, the word "Composition" was used in the beginning of the 19th century to account for a building's conception, details, and the whole. Leon Battista Alberti provided the definition of composition in his work *De picture*, 1435, specifying the order of a sequence linking surfaces, limbs, and bodies. Colin Rowe noted that in 1734 the word composition entered the English architectural vocabulary, "as a result of the formal innovations of the Picturesque, and that it was received as being particularly applicable to the new, free, asymmetrical organizations which could not be comprehended within the aesthetic categories of the academic tradition."[60]

Denis Diderot defined the word composition in 1753, highlighting a unity in which the parts integrate to the whole. The unity that Diderot called for in portraiture was the opposite of a gathering of different elements that did not form a single picture. Therefore, the question of unity in architecture was tied to the unity of composition. In that unity, the parts could form a whole but could not be added or taken away without the whole losing its coherence. According to Lucan, composition was defined as "close order". His conception held influence until the middle of the 20th C. Charles Blanc spoke of inviolate unity, "A structure is harmonious once all its members are so connected to each other that we not take away or transpose a single one of them without breaking up the unity of the edifice." École des Beaux-Arts professor Emmanuel Pontremoli declared in the first half of the 20thC that, "Compose …means to dispose the different parts of a

[59] Ibid., 20
[60] Ibid., 22

given edifice in such a way that the interdependence of each one of its elements result in an organized body where each one of them is placed so perfectly that any modification of change would seem impossible without completely ruining the equilibrium of the composition." André Lucat extended the meaning of the traditional conception of composition when he stated, "To compose is to combine, in a harmonic mode, elements as poorly matched by their function as they are by their size and shape in order to create a homogeneous whole."[61]

From the brief historical definitions of composition, we can see architectural composition was born by the increased complexity of functional programs and the desire to order the parts of a buildings relative to the whole [Figure 48]. Building elements, such as walls, doors, windows, porticos, floors, vaults, etc., are arranged and ordered following symmetrical principles, in which they cannot be divided in an overarching order. The fundamental element of architectural composition is a room or volume. This is similar to nature's use of cells in living organisms.

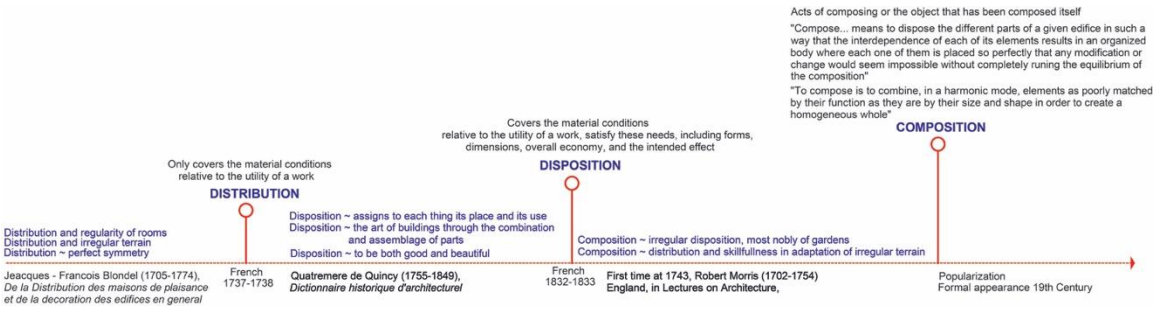

Figure 48. Notions of composition

3.2.2. Compositional structure

Modern architecture

[61] Ibid., 25

In modern architecture, form is stripped of decoration and obeys compositional principles. Modern composition is directed to an open order with free plans as the primary type, as Le Corbusier said, "the plan is the generator…. the plan is the basic… the plan determines everything; it is the decisive moment,"[62] In this sense, modern architecture remained in part influenced by ancient architecture, as seen for example in the Acropolis in Athens. The plan determines human perception, and is concerned with multiple points of view offered in an architectural promenade. In modernism, a dynamic perception became privileged over the prior static perception given by bi-lateral symmetry. [Figure 49].

Figure 49. Compositional modern morphology

Rhythm also impacts plan configuration, presenting an equilibrium arising from simple or complex symmetries or from formal contrasts. There are three types of rhythm: bilateral symmetry, compensation and contrast, and modulation and growth. Plan organization follows geometric rules and modular combinations of the parts.

A static architectural form in which space enclosed by four walls as seen in the classical period is rejected; instead, the whole plan is made free and dynamic. Skeletal structure is emphasized to express the contrast to plastic form, such as seen in Le Corbusier's Domino rectilinear skeletal structure juxtaposed with curvilinear walls. Sometimes, elements of composition, such as columns, beams, windows, staircases, are taken as syntactic elements to produce a different, modern, architectural language.

Figure 50. Architecture syntax

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[62] Jacques Lucan, "Convex Space: Le Corbusier and the Free Plan," in *Composition, Non – Composition: architecture and theory in the nineteenth and twentieth century* (Italy: EPFL Press), 367

Organic Architecture

Beginning in the modern period, mimicry of forms and the use of composition were seen to be unfit for contemporary needs, "Composition in architecture is, I hope, dead," Wright said. Architectural form was not seen to result from composition, nor was it understood as an assemblage of parts. Instead, form was proposed to be plastic, flowing and growing naturally out of functional and cultural needs. The life principles are expressed in geometry in all natural forms. Plastic organic forms result from a growing process, instead of from mimicry of a static form, and because they are based on the growth principle, they relate structural continuity with surface expression.

The organic whole is created two ways. The first one comes from a simple figure, such as a circle, square, or triangle. The second comes from a solid as cubical unit. These initially simple geometric units become more complex when transformed by rotational, bilateral, and translational symmetry.

For growth to be organic, it must follow freedom in its development, released from *a priori* limits imposed from the outside. Organic features are not finished, complete and closed. The form --what the principle of growth brought forth at the end of the process— is basically is no more than a stage of development of growth or decay. Often, growth occurs via "*centrifugal"* and "*centripetal"* processes. These are often witnessed in the works of Wright and Prince [Figure 51].

Figure 51. Organic composition

3.3. Natural structure and principle

3.3.1. Nature as Fractal geometry

Fractal geometry was invented in 1975 by the well-known mathematician Benoit

Mandelbrot [Figure 52]. Unlike Euclidean geometry, fractal geometry describes uneven, rough, and bumpy objects in nature, and describes their shape and structure. Fractals are constructed by starting with simple geometric units which are repeated in patterns of *self-similarity*. The patterns would be forms of point, line, plane, or solid. In building fractal objects, initial patterns are reiterated, and to fall into two cases: maintaining their similar forms, or transforming to their adjacent forms, with different ratios. To be like natural shapes, random factors are added to the self-similarity process by accidently repetitive steps.

Figure 52. Mandelbrot Set

The degree of regularity is always constant in all scales of ramifications. Each of their irregularities has a degree of regularity. When observing a fractal object, regardless of the reader's position, near or far, small details appear in the same way. Repetition of details stays in smaller details, the motif in the smaller motifs, until infinity.

Fractal structures are found in any fields, such as geology, botany, zoology, communications, imaging technology, economics, and architecture. Repetition and transformation of an archetype with a principle is found out in details of architectural ornaments, geometric modules of a buildng, and street patterns.

Other mathematician's work, such as the Von Kock curve, the Minkowski curve, the Sierpinski carpet, and the Tree fractal are typical other geometric tpes related to fractals that help to clarify natural structure.

Von Koch curve

In 1904 Helge von Kock developed the Von Kock curve, an infinite perimeter line based on a finite line. The curve is formed by: A straight line K, the initial geometrical pattern,

and is divided into three equal parts, then an equilateral triangle is constructed in the middle, the middle line is then erased to take the form K1. By repeating these steps over and over, the Von Koch curve is obtained.

If adding the rule with a random factor, such as, at the step of constructing an equilateral angle on the middle segment of the line, its position is located randomly above or below the line segment, a Von Koch coast is achieved. A Von Koch snowflake is formed if the original pattern based placed on all three sides of an equilateral triangle [Figure 53].

Figure 53. Von Kock curves

Minkowski curve

Hemann Minkowski formulated the Minkowski curve based on the Von Kock curve principle. The initial pattern is a straight line, which is then divided into 4 equal portions. The two middle segments are erased, and a square is built by three edges of the square in different sides in comparison with the original line. By repeating this process infinitely, the Minkowski curve is formed. If the rule is carried out randomly using a square as the initial pattern, and applied on the four sides of the square, a Minkowski Island is formed.

Figure 54. Minkowski curves

Sierpinski carpet

The Sierpinski Triangle was created by the mathematician Waclaw Sierpinski. The Sierpinski Triangle is based on an initial equilateral triangle. It is divided into four smaller equilateral triangles by three lines beginning from the midpoints of each segment that run parallel to the segments of the original pattern. Then the smaller segment in the midpoint of the segment is deleted. The Sierpinski Triangle is obtained if the principle is reiterated infinitely. If the initial pattern is a square, the result is a Sierpinski carpet. The

original shape is divided into nine squares and the small square at the pattern center is erased. If the pattern is a pentagon, the result is a Sierpinski pentagon. The principle can be applied for the initial patterns as the original image can be other polygons, such as hexagon, octagon, etc. Karl Menger applied the principle on a cube, and the result is the Menger Sponge [Figure 55].

Figure 55. Sierpinski carpet

Tree Fractal

The Tree Fractal is related to the Pythagoras tree created by Albert E. Bosman, in 1942. The initial pattern is a straight line. Two straight lines of equal length with the ratio 7 to 10 in comparison with the pattern are placed at the top of the pattern. The first line is rotated clockwise 40^0, and the second line anticlockwise 60^0. When this process is reiterated infinitely, a Tree Fractal is attained. If the initial pattern is three straight lines composed of three equal angles 120^0 and with two edges with a length that is half in comparison with the lines of the initial pattern, this forming a Triangle-tree fractal is obtained [Figure 56].

Figure 56. Tree fractal

3.3.2. Fractal characteristics

Fractal geometry has properties to describe and analyze how nature establishes form to facilitate growth and provide function. According to L. Fon Bertalarfy's definition of "systematic theory," the structure is the "set of relationships among modules or elements in its system." It is also which arranges relations among the elements and stays existence and basic properties of the system. Thus fractal geometry helps unlock the structure of natural forms, and can be applied to architectural form as well. The physical expression

of living forms is symmetrical shapes, and their fragmented shapes and combined harmonies are the result of self-similarity.

Geometric rules evidenced in natural structures are also seen in architecture, such as spaces, textures, and ornament. Fractal geometry parallel nature's laws, including the principles of repetition, ramification, transformation, similarity, dissimilarity and homomorphism, applied at all scales.

Following fractal principles, the process of growth in architecture can originate with a simple geometric shape which is then subject to a fractal transformation with a random factor added. Or the initial pattern may be applied to the whole initial form, which is then broken by fractal operations. The elasticity of form accords to different directions with different ratios.

3.4. Modern organic structures

Fractal geometry and natural principles reside in architectural compositions regardless of human consciousness or unconsciousness. Architectural forms result from forces, and the structure of composition relates to natural principle of growth. The similarity is due to the fact that humans are a part of nature, and human motivations of function, meaning, and aesthetics are undivided from the scope of nature's movement. The appearance of modern architectural composition and organic composition depict the distinct impacts of human and natural forces on form. Some forces are exposed and some forces restrained and intercede on composition in different variations.

3.4.1. City of Culture of Galicia, Spain

Dislocation and decomposition

The form, designed by Peter Eisenman, is proposed as the bastion of the location because it is rooted in presence as the shelter of an institution, and as a human embodiment, serves symbolically as the center of the world. To be integrated to its site, the concentrated form needs to be dislocated or alienated. Its non-rectilinear representation results from three overlaid sets of information: the street plan of the medieval center of Santiago, the modern Cartesian grid of these routes, and the topology of the hillside site. The process of composition uses decomposition in relation to a rational transformational process. The focus is given to decentralizing and disorienting the center of the object by removing traditional architectural strategies including anthropomorphic scale and customary use, such to present an objective and non-narrative space.

Eisenman established the sense of alienation in the form by imprinting the medieval street pattern on the opened folding planes that were in turn based on a rectilinear grid of functional spaces. Man fulfills himself through his conscious mind, realizing that the emptiness is in his internal world, here symbolized by the street alleys and the openings carved in the building roof. The feeling of alienation lies in between the conscious and unconscious mind. The alienation is repressed but is here surgically opened-up to find what is repressed. An excavation of the senses allows access into the unconscious past to give presence to new understanding.

Figure 57. De-compositional form

3.4.2. Walt Disney Theater, Los Angeles

The whole of dismemberment

Frank Gehry has been influenced by multiple artists and architects and their works, including Wright's Prairie Houses, Le Corbusier's Notre Dame du Haut church, abstract

paintings, and fish forms from Japanese woodcuts, He designs with the concept of using a cluster of objects, where the whole is taken to be greater than the sum of its parts. The composition is the result of the designer's rational and intuitive mind, although it is often explained as a symbol of a rose, depicting the client's love for her husband.

The structure is designed as a single volume that gathers cluster boxy forms around it. The central concert hall is oriented on a diagonal axis taken from the street corner. The hall and entry spaces are sheathed in curvilinear fish-like forms. The spaces between the box-like concert hall and curved forms allow visitors to contemplate life's disturbances and discord. The two orthogonal building boxes toward the rear of the site are juxtaposed with the diagonal orientation and re-orient the composition to the regular city grid [Figure 58].

Figure 58. The whole of dismemberment

3.4.3. The Eden Project, Cornwall, UK

Landscaping participation

The project, designed by architect Nicholas Grimshaw, is an example of place-making that orients to the future in the way it is integrated to nature. The entire composition is made by the repetition of a unit formed as a hemi-dome articulated by hexagonal and pentagonal inflated plastic cell structures that are supported by steel frames and cables. The unit is reiterated regularly into a single adjoined and interconnected composition that conforms to the site terrain, and merges with surrounding landscape.

The whole composition is informed by the principles of dissemination and equilibration. The form and its constitution mirror the functions of the building as a botanical garden.

Figure 59. Landscaping participation

3.4.4. Munich Olympic Stadium, Munich, Germany

Compositional framework

The project was designed in 1972 by Frei Otto in collaboration with Gunther Behnisch. It shows a recent evolution of tensile or tent structures. The large span building is the embodiment of the synthesis of architectural and structural form, and recalls membrane and tensile structure found in nature. Its form is a continuously suspended membrane like a spider web or tent caterpillar nest floating over the site. The tension net is clad with acrylic panels that reflect light, the sky, and the surroundings park site [Figure 60].

Figure 60. Composition framework

3.5. Composition of enviro-organic structure

The compositional structure of enviro-organic form is derived from the combination of modern compositional principles, fractal geometry, and principles of growth. Modern composition results from human's instinct to find equilibration, fractal composition is derived from human understanding of the natural, and structure based on growth comes from how humans comprehend the dynamic processes of nature between the earth and sky. The compositional structures may contain regular or irregular features in forming the whole. Such variation is dependent on the specific constellation of influence given by social-cultural force, gathering force, weather force, and psychological force.

If enviro-organic composition is organized by a volume pattern, it is first presented as an archetype that is subsequently transformed by environmental force. If organized by a whole, it becomes transformed in a process of growth and becomes deformed or fragmented. During the process of transformation, the characteristics of the composition as analogy, homology, and ramification are conserved, in which geometrical principles of

regularity and irregularity are strictly obeyed [Figure 61].

Figure 61. Enviro-organic compositional structure

CHAPTER 4. GEOMETRIC OPERATION AND ANALYTIC / SYTHETIC TOOLS, AND APPLICATION TO DESIGN EXAMPLE

4.1. An approach to enviro-organic practice

4.1.1. Creativity and forces

Architectural design is a process of creativity in which fantasy (dream and visions), imagination (what is there, to perceive reality, to recreate or to repeat reality), and reality (buildings) coexist with each other. Fantasy engages primitive environmental memories. They play a role as a catalyst or a power for imagination and belong to the sphere of the mind. The environmental force refers to man's ability to generate images that cannot become realities of buildings in any circumstance. As a guide of the creative process, organicism acts as the force for the imagination that relates to making the real. Environmental force and imagination together make buildings new or upgraded.

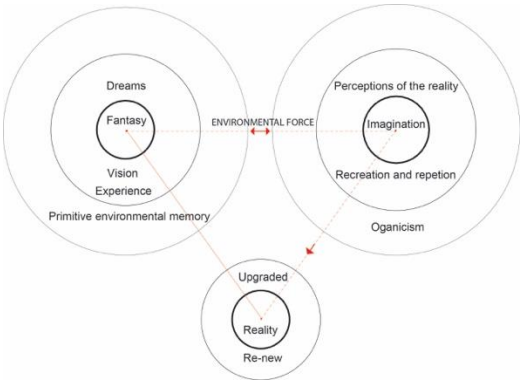

Figure 62. Force and creativity

4.1.2. Design method

Architecture forms have existed since the dawn of human inhabitation on earth. In human interaction with nature, form was produced using nature as the source. The forms were based on technical assumptions, with man's attention of how to learn from nature, and how to protect from nature, without attention of natural essence being in its growth

process. The process of growth in nature is dynamic and amalgamative, including many simple and complex factors of random motivations as momentum forces. Accordingly, architectural design should be a process that organizes and composes various interrelated forces of man and nature into a form unified with its built environment. This is in contrast to a prior process of design that arranges and composes functional and technological demands into divided whole soley to serve functional purposes of human life support.

The enviro-organic form method of design uses an investigation of forces that has the ability to avoid prolixity, such as unnecessary ornaments or irreducible forms, and promotes finding a truth in form, having simple and full interlacing relations. The previous design methods, normally, make form through a fragmented process focused on problems of symbol, function, and sustainable criteria. The enviro-organic form method follows previous methods, but goes further to incorporate nature's lessons of transformation and integration. Forms of nature are deformed morphologically under forces in certain circumstances for adaptation and fitness. The architectural object is considered as a connector among things within its place. It grows on the earth.

A static form can be reputed as a petrification at any stages of its movement. Its dynamic form is perceived psychologically from the growth of its conformation. In the history of architecture, fallacies of learning from nature resulted in the mere replication of natural curvilinear forms. Quite often, this mistake is repeated in contemporary architectural forms, even in pure Organic Architecture. Humans cannot make forms as good as nature, but within their possibility and reality, their architectural forms are metaphorical objects of nature, instead of natural entities *per se*. The metaphor connotes the whole purpose of function and aesthetics. The growth of natural forms is governed by equilibrium that

reflects into architectural composition, as growth, with principles of symmetry, asymmetry, fractal, and grouped structure.

This method is based on geometry for description and analysis, because it serves to guide and visualize transformations produced by forces. It refers to Thompson's method that used geometry to compare natural forms under altered conditions. Geometry helps to produce new form, transformed form, as anticipate deformation according to the dictates of reason and nature. Primary, ready-made forms are taken as fundamental geometries and taken as a starting point in a process of transformation. They are employed because they are user-friendly instruments for abstract expressions and imply concepts of proportion, golden numbers, and harmony of nature, and the unity between form, function, and structure in architecture.

The new approach discovers another dimension of form meaning in the built environment. The meaning of form is revealed by environmental force. It returns the form to genuine value or a true tectonic that would be unique and the focus of its site. Enviro-organic forms resulting from the method are the next stage of the evolution of architectural form. They present the unification among force, form, and function in their change of shape that the former methods have not yet been fully realized in architecture.

4.2. Organicism

4.2.1. Growth on earth

Organicism as "growth on earth" as a design method, under supplemental impacts of environmental force or earth force, will bring about enviro-organic form to its site harmoniously as the whole ordered and fragmented, in which compositional, fractal and grouped laws are maintained for the whole composition. To execute the concept of an

organic whole, a geometrical object as a functional and formal unity or as a cell of the composition will be selected, then, it will be transformed in its natural environment.

In the form, aspects of human, dwelling, building, earth, and sky are unified. These aspects reference to people and meaning revealed by human response to an environment that frames daily living. The form serves to connect humans and the preexisting aspects of a site.

4.2.2. Concretization of place

Concrete forms influenced by environmental force can be defined as the images of environment that are presented as existential spaces. These spaces are psychological concepts or schemata that humans develop in their interaction with the environment. It concludes man's wishes and dreams. Because humans seek to always improve their environment, the forms of spaces concretize images in which the existing environment is reflected to match with human skill and technology. The structure of concrete forms thus can be determined by the concrete structure of the environment.

Environmental structure is determined by roads, paths, and their orientations attached to geometrical and topographical form of a place. They play a role in guiding the connection of enviro-organic form to its site, and serve as the reference for the deformation of form. Axes are used to direct, orient, and relate forms. At the cores, the variables and invariables of form are located, and become the nodes of horizontal and vertical circulation.

4.2.3. Form transformation

According to D'Arcy Thompson, in nature, transformation is a process and a phenomenon of the change of form under altering circumstances. At any given time, form

can be described by dual methods, descriptive and analytical, in which the former is assigned to the use of words and the latter the use of numbers, mathematics, and the Cartesian coordinates. In enviro-organic form, transformation is defined as the process of form deformation whereby the form reaches its ultimate state by responding to human and natural forces through principles of analogy and homology.

According to previous studies in the topic, three strategies of deformation are learned from the continuing of organicism in architectural history and nature. They can be summarized and applied to an enviro-organic form in the following orders:

a) The rational-empirical strategy

b) Environmental reflection

c) Decomposition or re-composition of the whole

With the rational-empirical strategy, the progress of formal evolution is adjusted step by step to adapt to the external impacts of human and natural force, such as site view and orientation, prevailing winds and environmental criteria, function and program, and two or three dimensional properties of selected initial form. Borrowing principles from painting, sculpture, objects, and other artifacts is also done according to their applicability and validity. Psychological force of aesthetics participates in the category at the will and the attitude of architect, in conjunction with the consideration of pragmatic criteria.

With the environmental reflection strategy, the environment becomes the basis for deformation and the metaphor of a house. The environment as a whole is observed for informing the selection of structure and geometric shape. Those are imprinted on the

house. Here, the house is considered a reflection of its garden, and imbedded in its constitution. This is the case of 'pictorial transferring' of landscape, or as a 'pictorial metaphor'[63].

During the process of the reflection, the essence of environmental things is objectively described, including universal and particular characteristics. The architectural object is historically investigated via our memory in terms of place and time. In the journey to the past, structures of architecture are observed and recorded. Depending on our needs of meaning, form, and program, one precedent would be selected. To reach form by analogical and homological means, organic methods of environment as slice, void, and imprint are applied in the process. To practice this strategy, following steps are proposed:

a) Simultaneously carry out cognitional reduction and deductive postponement into phenomenal memory (free from our prejudice)

b) Record free variations of the past

c) Receive primitive intuition of the essence

d) Objectively describe concept-out of idea

With the decomposition/re-composition strategy, based on the environment, the deformation process deconstructs the whole, or constructs a whole by aggregation of its elements. The organic skill as dissemination is applied, following to compositional and fractal principles in order to find new ways to compose the parts and to evolve new wholes and new orders under forces cases. In the case of geometric patterns,

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[63] Anthony C. Antoniades, "The Chanel of Transformation," in *Poetics of Architecture: Theory of Design* (New York: Van Nostrand Reinhold, 1990), 66.

composition is aligned to the structure of the environment via connections to its elements [Figure 3].

	Form transformation					
Strategy	The rational-empirical strategy	Environmental reflection				De / re composition of the whole
Method	Application of human architectural criteria in design	Reduction and deductive postponement of cognition of environmental phenomena	Record free phenomenological variations of the past	Receive primitive intuition of the essence	Objectively descriptive concept	A whole broken or a pattern multiplied
Organic form	Equilibrium composition	Analogy and homology / Fractal principle				Dissemination of elements

Table 3. Form transformation

4.3. The whole of forces, form, and function

The organic whole is dependent on utilitarian force and aesthetic psychological force. This applies to for simple or complex building: dwellings, temples, and meeting houses. It can be a geometrical pattern or a geometrical object that is selected and placed in a site. In complex buildings, the geometrical object will be divided in species and connected with regard to new ways of constituting an organic whole. In different types of buildings, geometrical spatial forms are partitioned by moveable screens, and the scale of building can change when functional spaces need to be extended for adaptation to varied uses.

Socio-cultural force affects the shape and growth of the whole as well as the position of elements positions because it affects the arrangement of functional spaces, and the aesthetic arrangement. The socio-cultural force here joins in the composition of enviro-organic form. Similarity, ramification, gathering, and reiteration are the organic means of composition. All methods are arranged by the psychological force of equilibration. Socio-cultural force also influences on form in terms of proportion, structure, and material.

However, material is not applied for the socio-cultural force. The geometrical object based on Platonic geometries together with golden ratios bring the proportion for form because they are simplified from nature's shapes on earth and sky by man's observation for survival purposes. Depending on the building type and form, structural forms as mentioned in Chapter 2, such as shell, fabric, catenary, rib, arches, frame, wall, and tree structure will be chosen for the integration of architectural and structural form.

The remaining forces as environmental force and weather force impact the geometrical forms with respect to environmental history and myths, topographical and geological formation, tree and sky, climate, rainfall and winds of the site. The force dynamics of the site's environment impact and open the architectural form. Weather force is concretized in the shapes of the form as sloped / flat roof and eave, courtyard and lanai, path and steps. Environmental force is located in the strategy of environmental reflection. It creates form as solids and voids via skills of slice, hole, and imprint. The entire of form presents as the whole with geometrical synchronicity, integrating to the environmental shapes.

4.4. Combinational forces on form

The relation of the three forces corresponds with the relation among human, earth, and the sky. Functional forces pertain for human beings, environmental force for earth, and weather force for the sky. Of the functional forces, dwelling force evolves to utilitarian force and gathering force evolves to socio-cultural force due to the human evolution of perception. Thus, human force includes utilitarian force and socio-cultural force. Those forces are manipulated by psychological force embodied as symmetrical and asymmetrical laws in composition. The environmental force is governed by a grouped

principle and weather force by emanating in vertical and horizontal directions.

The forces on form consist of human force, earth force, and heaven force. The forces are not separate in fact, but act in pairs, like in the relation in between the earth and the sky, mother and father, water and fire, and so forth. The forces on form thus follow the rule. Accordingly, the force combinations encompass the cases of human, human and earth, human and heaven, earth and heaven, and human, earth and heaven. In those cases, the combination of human, earth, and heaven force is the most organic and fullest meaning. Depending on private or collective demands, the combinational case is selected to make enviro-oganic form [Table 4], [Figure 63].

	Human	Earth	Heaven
Force	Utilitarian force Socio-cultural force	Environmental force	Weather force
Composition	Equilibrium	Fractal and group	Vertical and horizontal attraction
Geometric element	Platonic geometry	Euclidean geometry	Non-Euclidean geometry
Psychological force	Equilibration	Dynamic in static	Change undetermined
Combinational cases and organic criteria	● ●● ○○○○ ●●●●	○ ●● ●●● ●●●●	○ ○○ ●●● ●●●●

Table 4. Combinational cases of forces

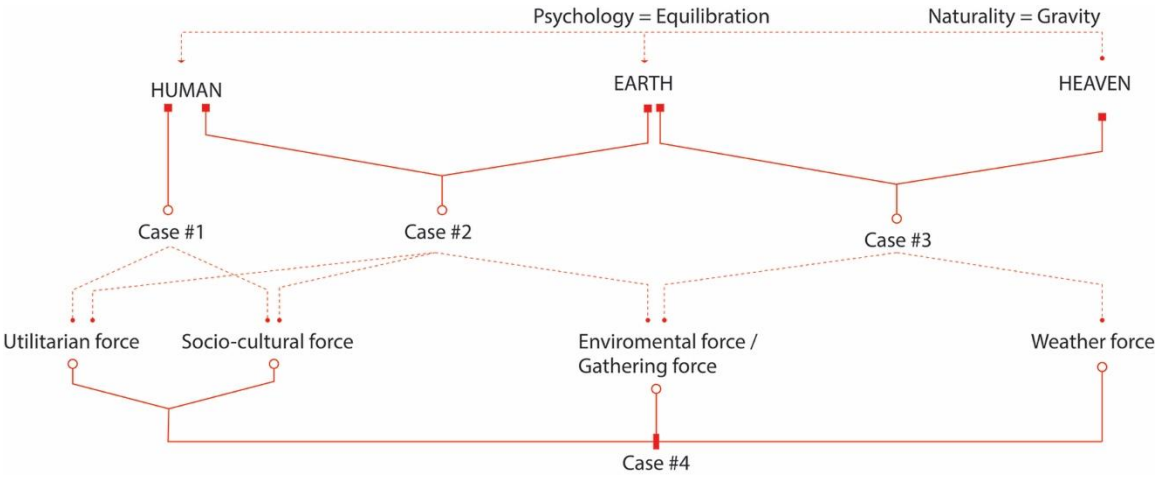

Figure 63. Diagram of force combination

4.5. Geometric organic operations

4.5.1. Method

Principle

To practice the concept of growth on earth in both vertical and horizontal direction, the practical way of the modes is based on Boolean operations on volumes (union, subtraction, and intersection), embranchment, gathering, and repetition are carried out simultaneously. Mental and physical forces are also controlled by psychological force of aesthetic as equilibrium. Elements of form are attached to structure the whole and they are balanced around its centrality, following bilateral, rotational, and translational symmetry. All these principles are applied to the process of design of growth on earth.

Manipulation

The design method of an enviro-organic form is concretized and undergoes the analytic processes of the rational-empirical strategy, environmental reflection, and de-composition as following:

a) Choose a site
b) Decide programmatic type of building
c) Envision the possibility of forces on form, such as functional force, social-cultural force, weather force, gravity force and environmental force
d) Select a geometrical volume influenced by those forces as a paradigm
e) Envision the influence of site environment that can work with such a paradigm
f) Manipulate selected geometrical space in 3-D per its site influences
    - Unify individuals while identify holism as focus of attention
    - Define space interaction while expanding selected geometrical space.

g) Determine the building status of form, function, structure and its environment logically, integrally, harmoniously, and aesthetically.

4.5.2. Growth skills

From the observation of organic archetypes in Chapter 3, the natural forms of the living growth on earth manifest themselves in curvilinear shapes, voids, and holes. They result from adaptation and fitness to the natural environment as well as their symbiosis at their site. Their manifestations of growth as organic processes are always in flux. To make the environmental influence on form effectively, the following tools are applied:

Slice

The Slice tool or method uses an object to cut other objects. The employed objects are the linear, curved plane, and volume that stand for environmental shapes, for instance geomorphology, mountain, tree, or amorphous, such as wind and water. This tool is used for geometric refinement of an initial pattern or the division of a whole. Afterwards, manual operations such as twist, bend, and taper can be applied for these processed objects. The purpose of the tool is to align architectural form with environmental form in both vertical and horizontal directions. Also, it cooperates with cultivation skill to divide the whole into pieces and re order it in a new way [Figure 63].

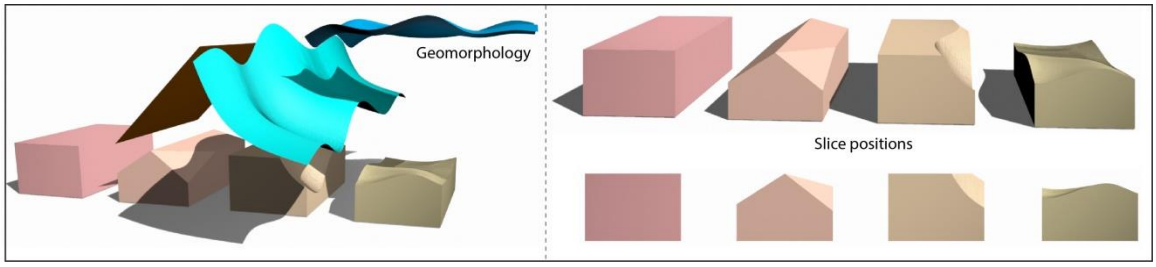

Figure 64. Slice positions

Imprint

Imprint interferes in the process of conformation when the built environmental structure is linked to formal composition. The operations of union, subtraction, and intersection of volumes are carried out on geometric forms of architecture and nature. Imprints can be seen in overlapping grid systems of historic structures on a site. In some imprint operations, the holes may be formed and these may result from functional demands, such as courtyard, entry, corridor, lanai, or veranda. The imprint manner aims at an oriented articulation to the built environment.

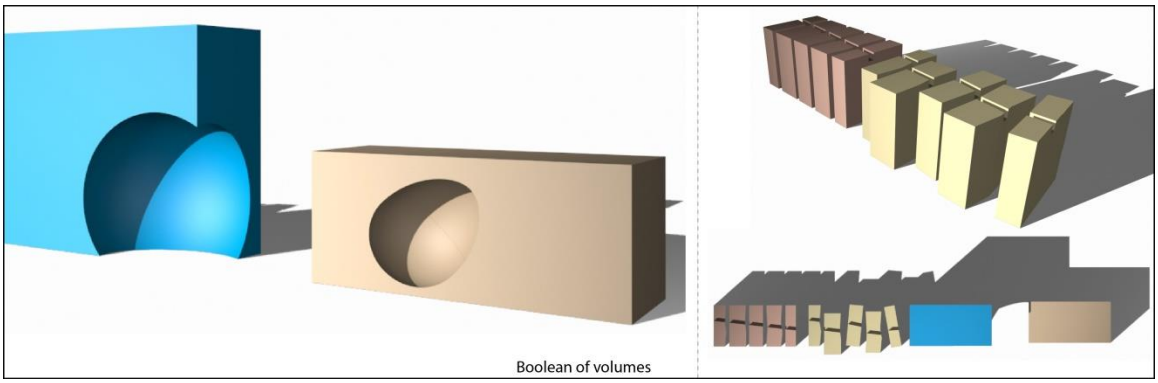

Figure 65. Imprint cases

Void

The Void tool is the way to make primary hollows on form for vital atmosphere. They recall primitive memories of days when people were wanderers on earth. The operation is understood as the bridges from one form to another. They are linear bridges or curved bridges if their edges are filleted. Here, the elements mentioned above as corridor, lanai, veranda, balcony, garden can be located or go through [Figure 65].

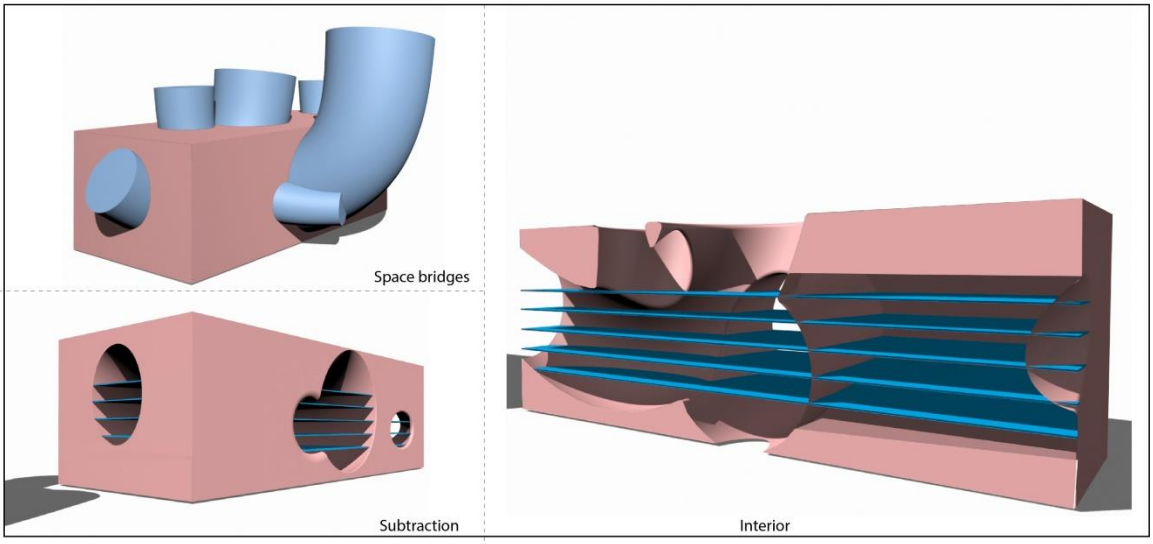

Figure 66. Voids

Cultivation

The cultivation or dissemination tool is applied for the earth influence of living behaviors on form. Refined geometric patterns are disseminated following compositional and fractal principles. The tool serves to provide a natural-like gathering of a composition and its growth. An assemblage is the phase of a ramification and reiteration. It can also be made by inserting a new form into a composition after some its elements are eliminated.

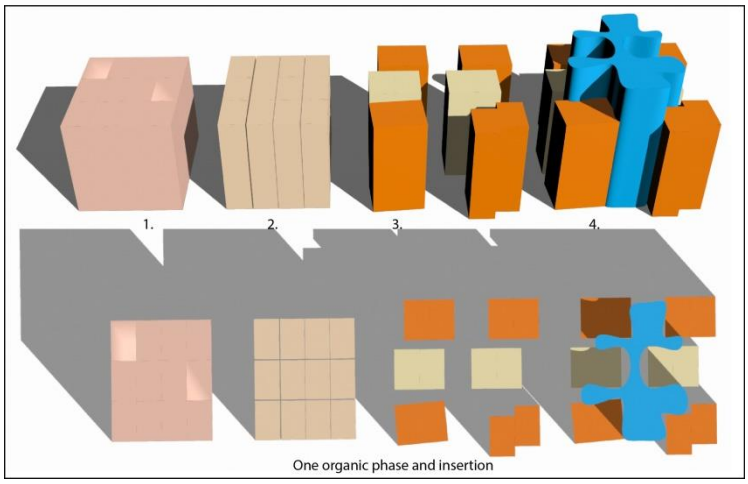

Figure 67. Cultivation

4.5.3. Applied tools

In enviro-organic design, the combinations of forces, their magnitude, and direction are different depending on circumstances, As mentioned above, there are four composed cases of force on form: human forces, human and earth force, human and heaven force, earth and heaven force, and human, earth, and heaven. Some forces are always present and some are intermittent. Human force and weather force are always included because architecture originates from human needs, whereas environmental force is mitigated in the urban context. The irregular appearances of forces also happen in each combination, such as, in the combination of human force, socio-cultural force is ignored when form is primarily utilitarian. In this case, in comparison to organic criteria, form is un-enviro-organic.

The three cases of the following tools are as the universal guides for making enviro-organic form under forces. In these cases, the geometric unity of form and function are selected first according to the strategy invoking functional space, and where it will then be deformed in different contexts such as city, country, and highland under the other forces.

City context

In the city context, utilitarian force leads the formal selection of the whole or initial pattern to the basic volumes. Socio-cultural force dominates on form transformation with city background if environmental force equals zero when the site is even and flat and has no natural landscape. Different geographic positions, weather force impacts on form in the envelope skin and intermediate spaces, such as close form and high pitch roof if in a cool zone, and opened form and slope roof or flat roof if in a tropical zone. After that, gravity leads to a relevant framework for the deformed form. Usually, the combinational

case between force human forces and heaven force constitutes the form.

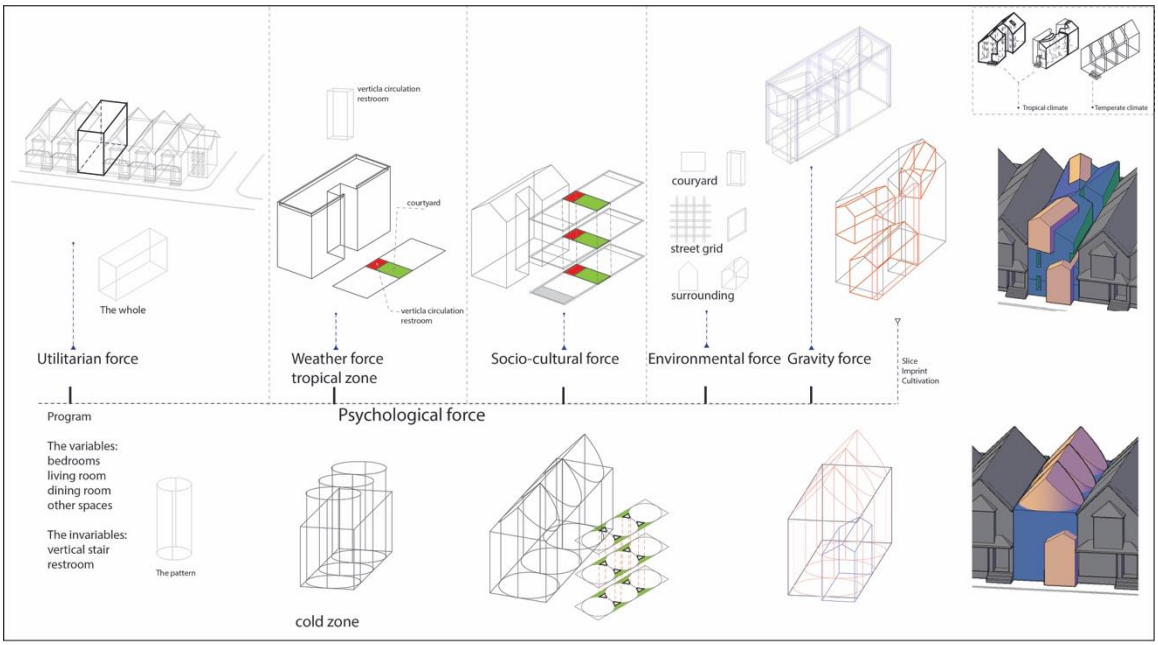

Figure 68. City tool

Slice, imprint, void, and cultivation tools are applied in this case. Linear or curvilinear forms may be used depending on the city surroundings and the road shape. Also, it is influenced by the designer's conceptual narrative. Socio-cultural force determines the structure of composition. Form location can be attached to the whole composition of the city. The street structure of the site is brought into the form by the first one, unfinished form is made by the void or its bridges. Its elements follow symmetrical principles. Yet the form could be smashed in pieces by the street imprint, and then they are reconstructed by compositional and fractal principles with dissemination skill through the locations of the invariant parts.

Country landscape

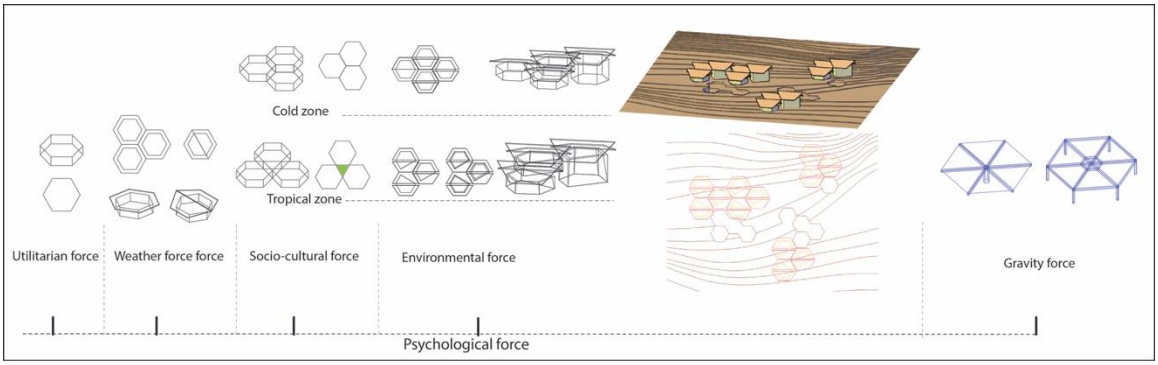

Figure 69. Country tool

Similar to the city tool, in country context, utilitarian force dominates in the selection of initial form to serve the unity of form and function. Socio-cultural force participates in formal deformation in the choice of roof, skin, and compositional solutions. Weather force determines the shape of roofs and social spaces, such as lanai, veranda, or courtyard, in conformity with climate zones. Ultimately, the form skeleton is constituted by gravity force. Differently, because of the intensity of the surrounding growth, environmental force becomes the main force on form deformation. The environmental force primarily brings site surroundings or landform on form. It can be influenced by amorphous form, such as water, cloud, or wind flow. In the case, the force combination includes human forces, earth force, and heaven force working together. However, their magnitude and direction are different due to the intension of the designer.

Slice, imprint, and void tools are chiefly applied to inflect the form to the environment. To attach the form to the site, the road system is imprinted as if piercing the form. Through cutting and hollowing strategies, form matches with landscape shapes and their growth. Under socio-cultural and environmental force, form composition can be generated from modes that conform to principles of bilateral, translational, or rotational or their combination.

Highland

The combination of forces that apply in this context is human forces, earth force, and heaven force. In common with the country tool above, in the highland tool, the unity of form and function remain with the selection of an initial geometry. Socio-cultural force impacts the selection of the whole or pattern for the unity. Weather force joins in shaping the roof and social spaces, such as veranda, patio, or courtyard, in conformity with climate zones. In this context, environmental force is predominantly geomorphic.

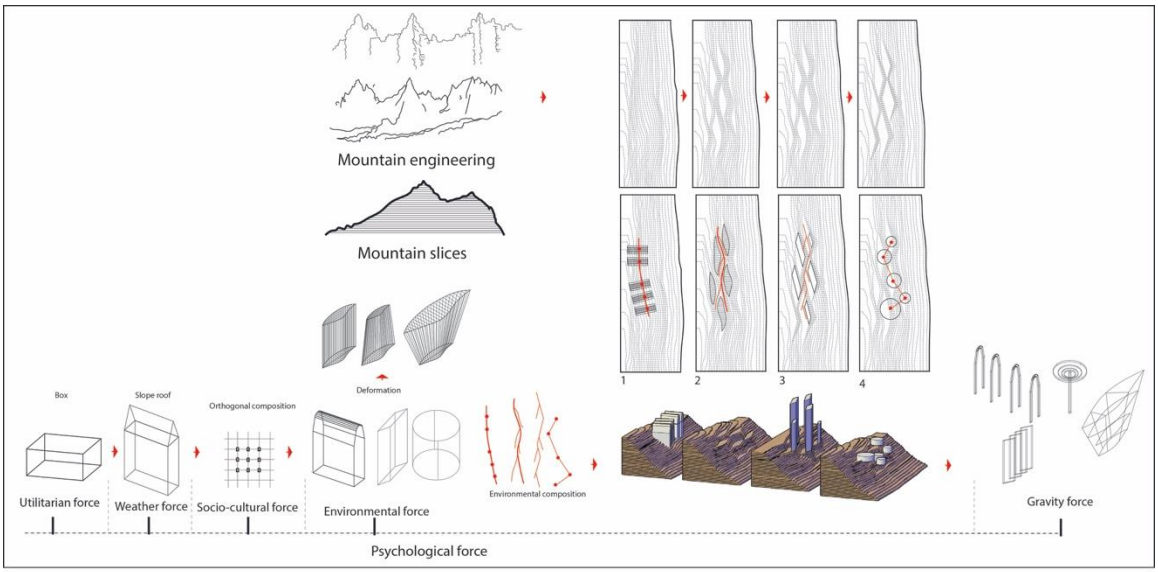

Figure 70. Highland tool

Slice, imprint, and cultivation are mostly employed to help form integrate to landform. The form will be located at the end-point or in a point along one of the site roads. Under environmental force, combinational structure follows terrain shape and structure.

4.6. Design example of enviro-organic form

4.6.1. Site selection

Hawaii's Plantation Village, in Waipahu, Hawaii, was selected as the site for application of the country tool because its characteristics of function, weather, socio-cultural, and

environmental forces are very clear. There are twenty-nine small structures for memorial exhibitions of World War II on the site. Near the site entrance, the main house is used for an art kindergarten and historical exhibition. In front of the building, there are Taro plantations. Currently, there are many educational activities that occur both inside and outside.

Figure 71. Site selection

4.6.2. Force, form and deformation

The outside influence

Utilitarian force

The building selected for design is called the Cultural House of Agriculture. The purpose of the building aims to highlight the value of plantation in students through education in history and cultivation. Accordingly, the program of the building consists of spaces for

agriculture exhibition, farming education, memorial space, and vegetarian food. It will be a future building that connects to existing structures of the past and present and the taro stem field. With the motivation of the utilitarian force, functional diagram of the building is preliminarily as following [Figure 71],

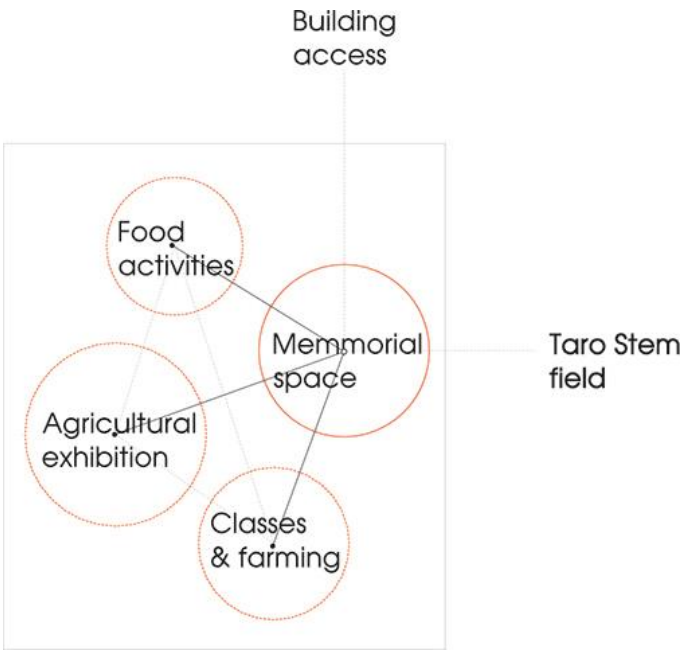

Figure 72. Functional diagram

Memorial space is proposed as a hub with other functions seen as its satellites which can rotate around the hub to adapt to weather and socio-cultural force. The functional program is in the form of a box and placed in the site location for deformation [Figure 72].

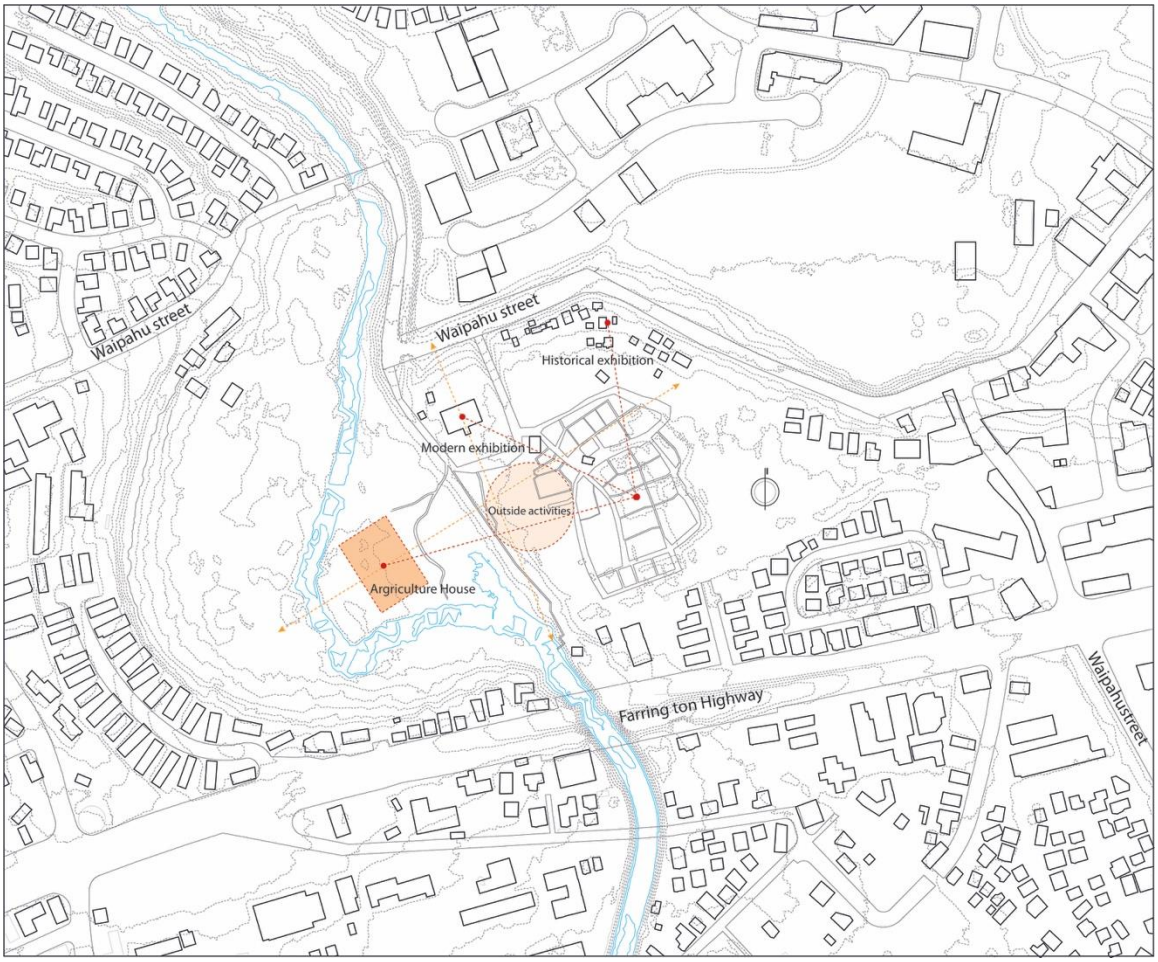

Figure 73. Site location

Weather force (Tropical zone)

The influence of the tropical zone leads to the possibilities of courtyard, flat and slope roof present in the existing forms [Figure 73]. They are used for adaptation to effects coming from the sky. The selection of the roof solution depends on roof forms of existing structures. The courtyards are located between food activities and agricultural exhibition, and classes and farming. The courtyards provide natural ventilation and day lighting [Figure 74].

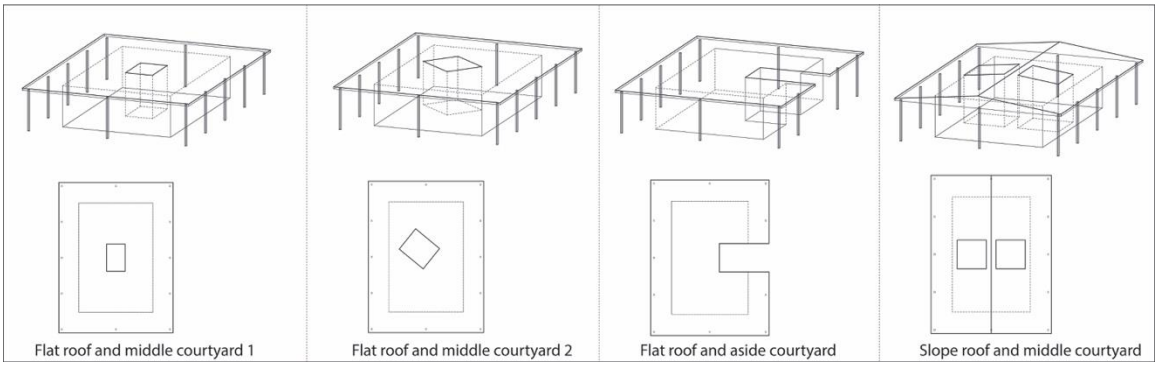

Figure 74. Shapes of roof and courtyard

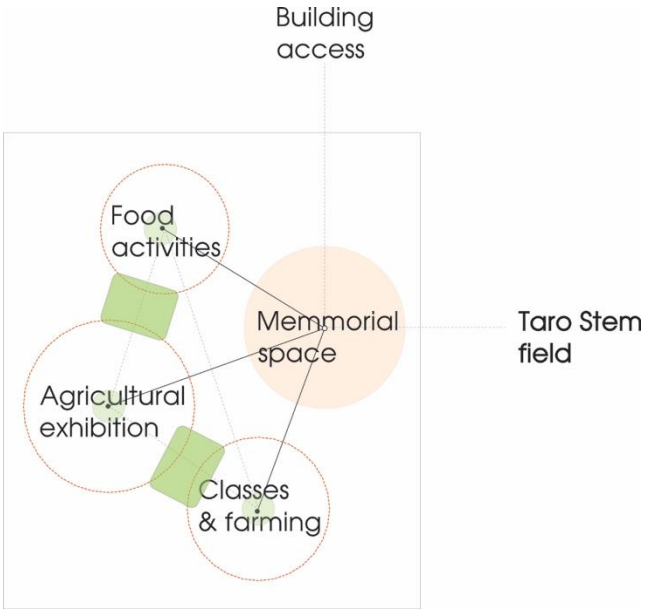

Figure 75. The adaptation of utilitarian force to weather force

Socio-cultural force

The force results from the observation of existing compositions in which the habit of used spaces displays in spatial forms and their connection. At the site, geometrical spaces are rectilinear forms composed in a linear fashion and covered by intersecting sloped roofs. These spaces orient to the south for shading and lanscaping.

The existing taro stem field serves as the core of the site. However, the site composition is not in balance because of sloping location of the modern exhibition space. The addition of the Argriculture House is another aspect of the socio-cultural force to the site

combination equilibrium [Figure 75].

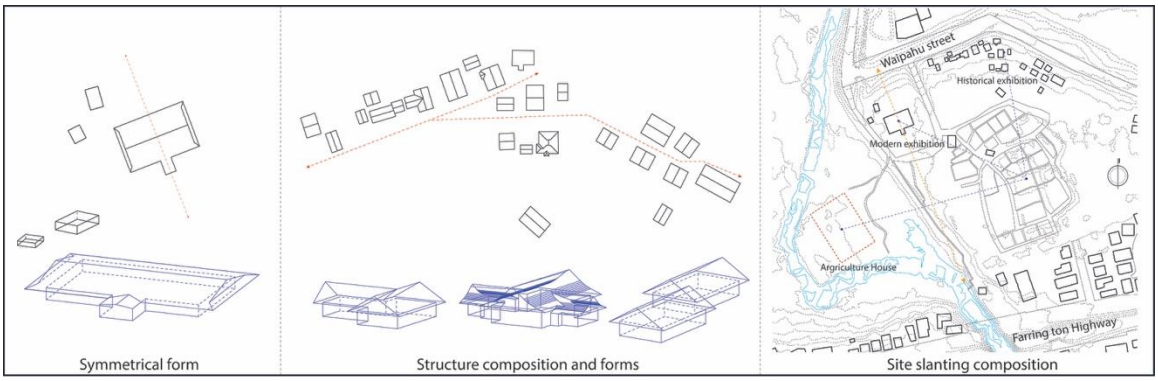

Figure 76. Influence of socio-cultural aspects

Environmental force

The impact of environment includes the horizontal and the vertical. To the former, they are already present in the whole surrounding of the site. The deformation of the form is based on the forms of the existing site elements that consist of the road system, terrain, stream, and plantation. Within the site context, the building is first inserted as a box and placed in the location that acts to balance the site forces. It is deformed following the terrain and stream shape. Next, taro stem roads are overlaid over the box and connect to the stream. Then, the box is fragmented according to the taro stem shape and rearranged with the requirement of utility under psychological force.

The vertical influence of the environment is determined by sections. They show typically the impact of the sky on form in the site. If the horizontal makes the form deformed on the body, the vertical makes the form deformed on the top.

The transformation in the site follows the natural principle of analogy and homology through the reiteration of courtyards and spaces. After deformation, the structural form is selected in shell, frame, and tree by gravity force. Finally, the deformed form is updated

in the site plan [Figure 76].

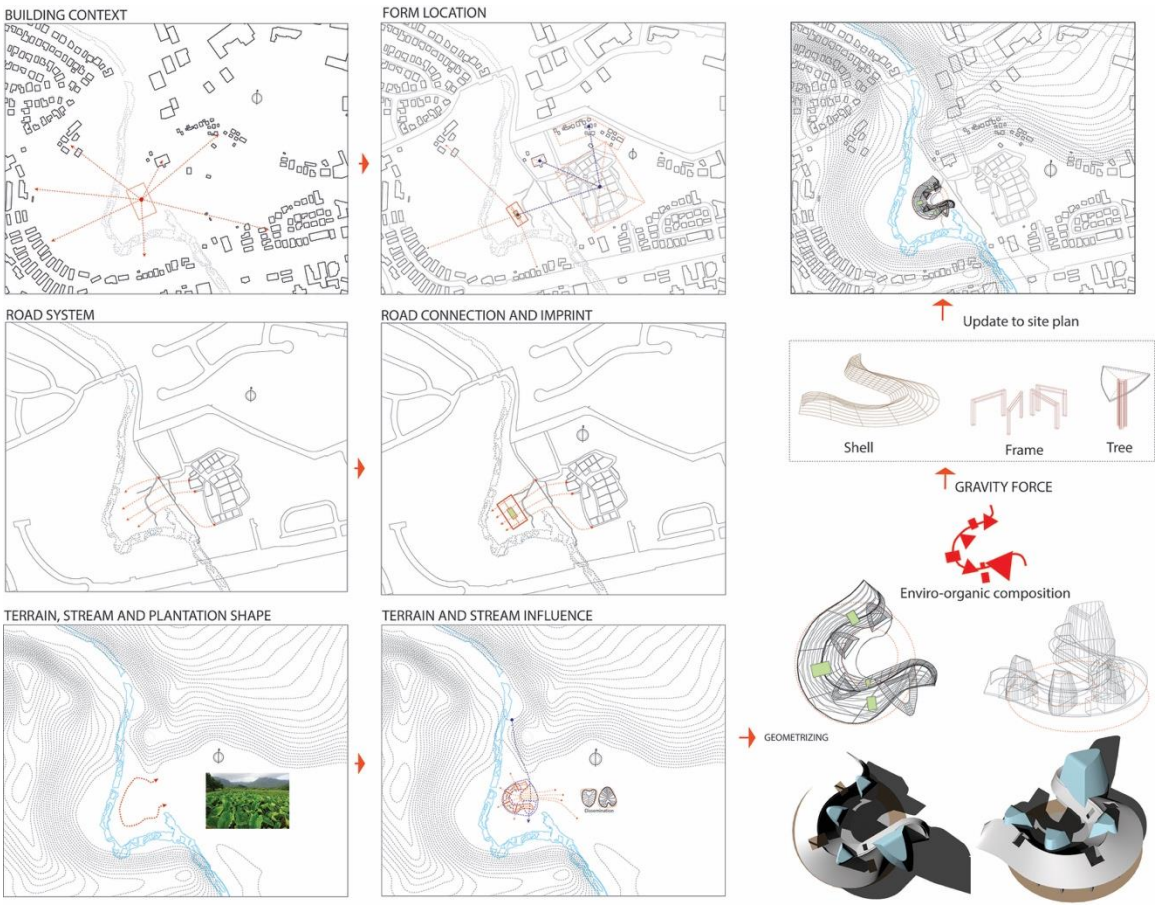

Figure 77. Form transformation in the site

The inside impact

The form is transformed under inside forces of utilitarian needs, thermal comfort, and view prospects. The exhibition spaces, public spaces, plantation areas, and classes require opening to the stream and taro stem field for wind and sunlight. These spaces are re-arranged to adapt to the interior demands of communication among humans and nature. The form of the transformation is the result from the integration between the outside and the inside forces or between human and nature forces.

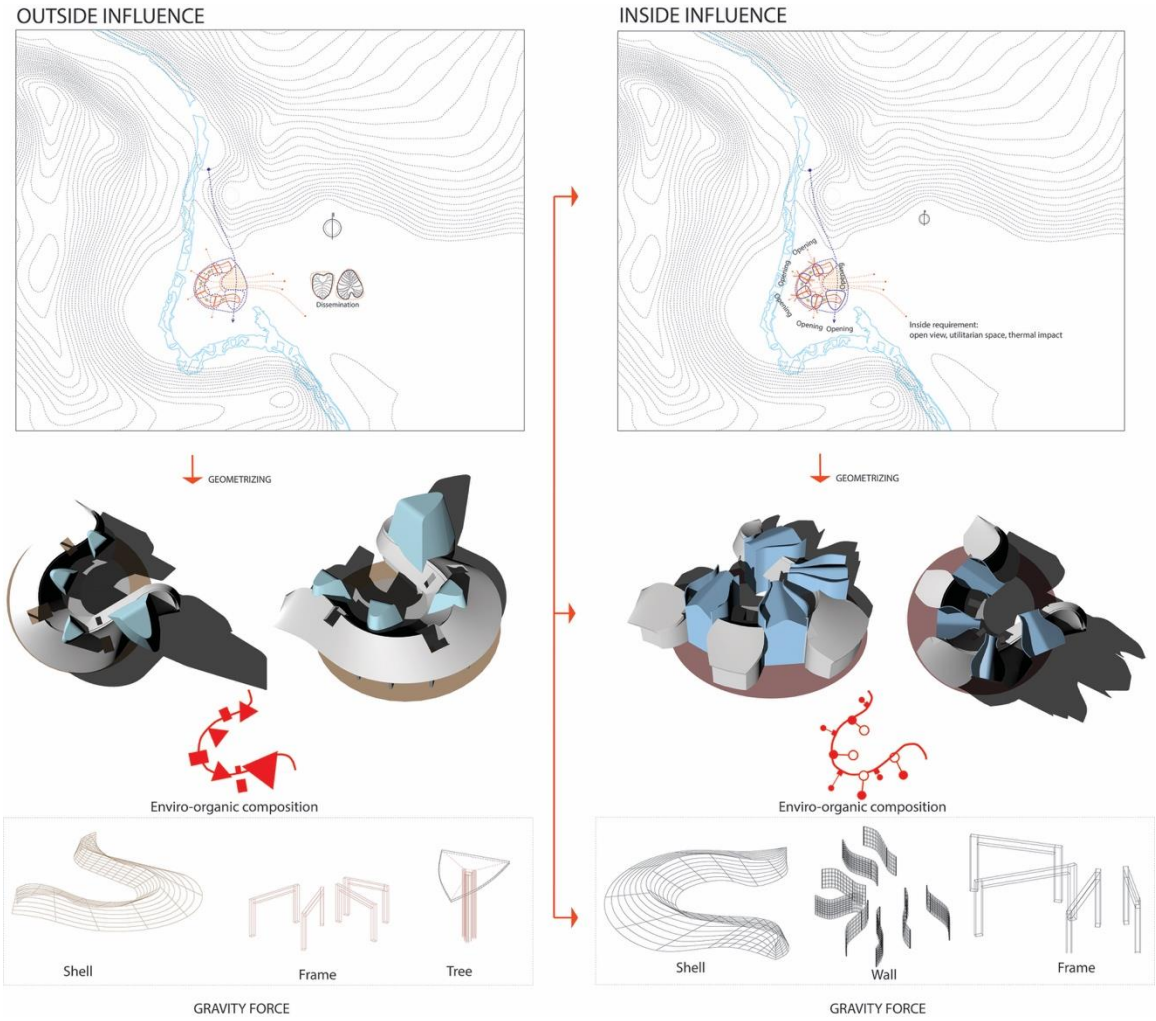

Figure 78. The form integration between the outside and inside forces

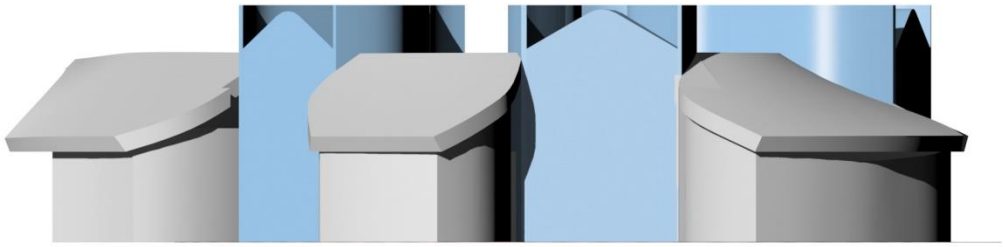

Figure 79. Form elevation from the stream

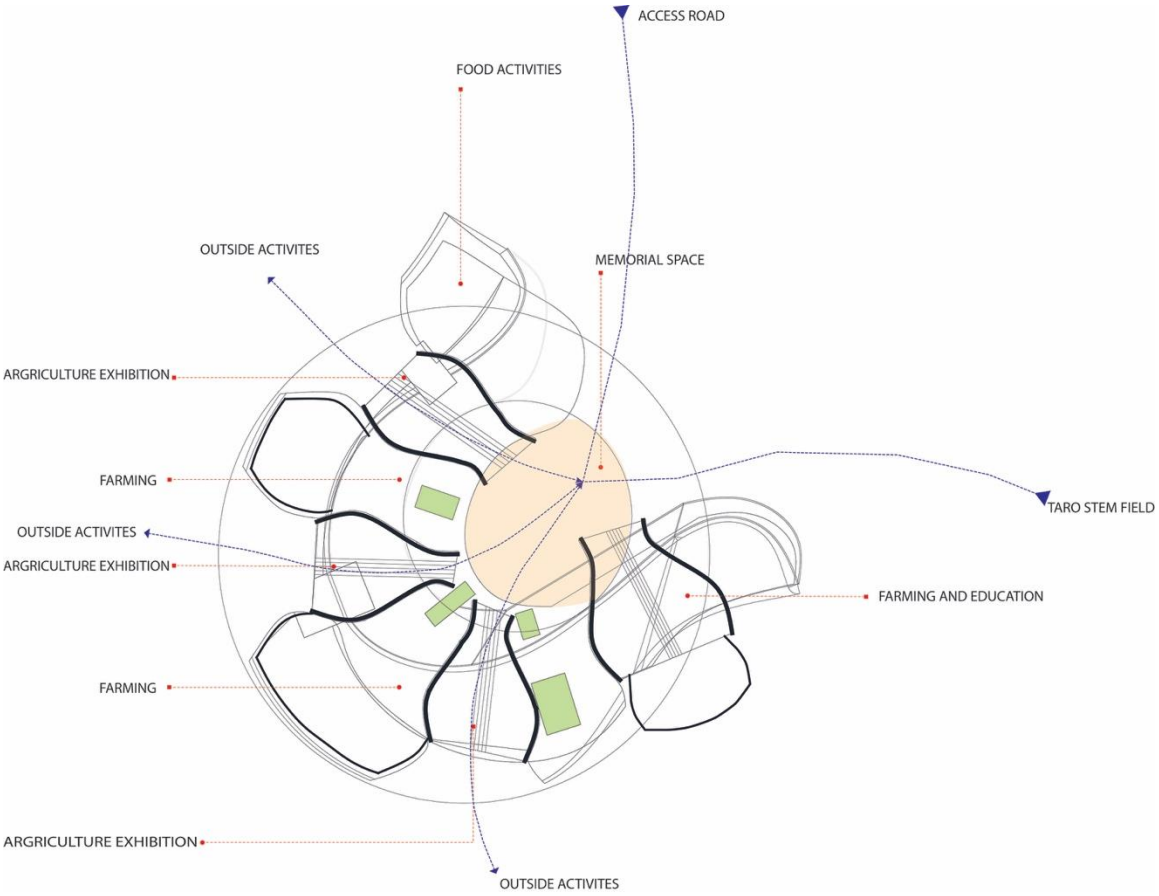

Figure 80. Floor functional diagram resulting from the integration of the outside and inside forces

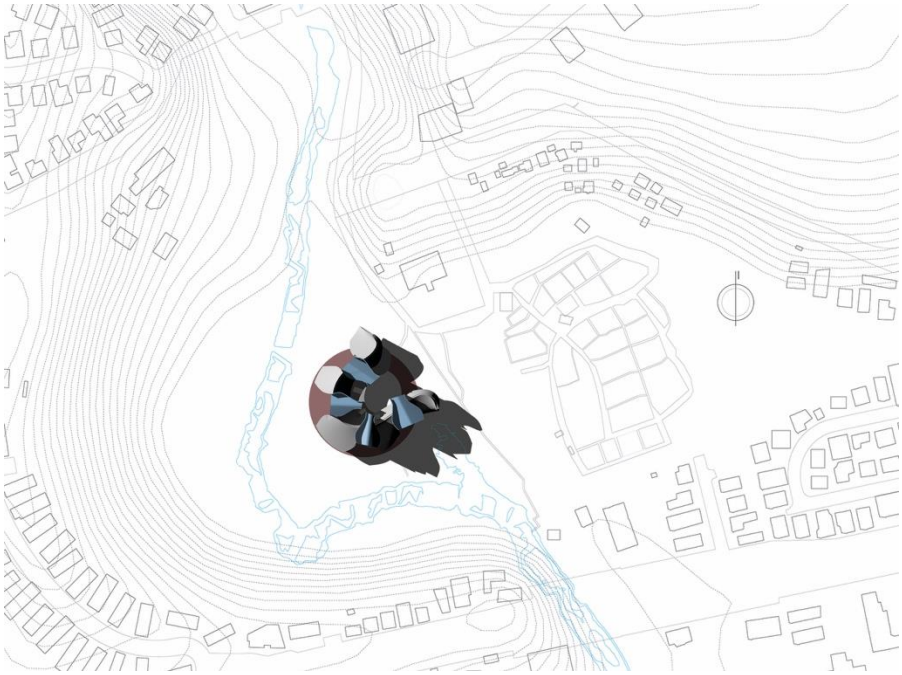

Figure 81. Master plan

CONCLUSION

Organicism is the result of human interaction to nature. From mimesis to imitation, organism flows continuously in human life and is always applied in architecture and other human productions. Organicism not only includes aspects of the natural, but also rational aspects, such as useful form, function, structure, and symbol. It unfolds the integration of humans to nature, with architecture being one of the results. Enviro-organic form is not merely organic or rational but amalgamative. The degree to which the organic is enmeshed in the production of form depends on human need and cognition experienced during human evolution. The enviro-organic approach is proposed as a means to bring humans closer to a richer and fuller organic horizon. This approach is argued to be a promising direction for future architecture. It shows human potential in connecting earth to sky in making his dwelling in the world.

The approach of basing form making via response to forces objectively brings to form the full of characteristics of architecture itself as a place. Human form is therefore more closely aligned with natural objects by their shared character of being “growth on earth”. Cultivated by humans, form grows from the earth’s impact, and is in turn impacted, by the enveloping natural environment, understood as the horizontal, and by the sky as the vertical. This is the complex organic interaction in a universe replete with the relations of human, earth, and heaven. The simplification of the visible and invisible by forces helps engage the levels of the organic and manipulate them through formal transformations. Such transformation involves psychological and physical states acting with cases of force combination, such as human force, human force and earth force, human and sky force, and human force, earth force, and sky force.

Like other living creatures, enviro-organic form is a process structured by initial inorganic patterns. Analogy and homology, or repetition and embranchment, are principles of pattern generation in the transformations. The pattern can be a geometrical object reflected from nature, human needs, or both. The unit or its whole stands for human demands of centralization, dwelling and adaptation. The whole can be deformed to integrate to the built environment through human agency. Forms may be split, and/or connected to achieve fitness under human and natural forces.

With the approach of form evolution under forces, the design method is proposed as fully effective in architecture because of its clear hierarchy in practice. It brings about the unity of form, function and force by the process of a rational strategy, environmental reflection, and de-composition or re-composition. The form responds to human demand for meaning embedded in form in its place. For humans, environmental reflection is enmeshed in their historical reflection of the built environment. The form – being derived from an enviro-organic process – may aptly satisfy architectural standards of uniqueness, stability, plurality, and communicability.

The enviro-organic process or method is unfinished because it has not yet included factors including different cultures or climates, and the habit of designers. The aspects of environmental reflection are complex as they depend on historical investigation and cognitive processes of humans. It is further difficult to rationalize the sequence and relationships between the exercise of slice, void, imprint, and cultivation skills. Yet, in different situations and circumstances of location, these tools can be applied to design innovation in an enviro-organic form making process that leads to desired outcomes for form-environment integration.

Finally, it is argued that the enviro-organic form making process may be useful in architectural education, as a means for students to understand how to create organic form as a result of forces. In distinction from modern design methods, the enviro-organic method directs to synthesis of form and function through a process of transformation with the participation of human, earth, and sky motivations acting together. To achieve enviro-organic form, the method divides the process into different steps and modalities, governed by the psychological force of equilibrium and shape. The approach using geometric principles and manipulation assists the designer to understand and the universal character of the organic, the unity of form, function and force, and the integration between the forces present in the interior and exterior of a building.

BIBLIOGRAPHY

GROUP 1 - ORGANIC ARCHITECTURE BOOKS

Eck, Caroline van. *Organism in Nineteenth-century Architecture: An Inquiry into Its Theoretical and Philosophical Backgrounds*. Amsterdam: Architectura & Natura, 1994.

Gans, Deborah and Zehra Kuz. *The Organic Approach to Architecture*. Great Britain: Wiley-Academy, John Wiley & Sons Ltd, 2003.

Pearson, David. *New Organic Architecture: The Breaking Wave*. London: Gaia Books Limited, 2001.

Thompson, D'Arcy Wentworth. *On Growth and Form*. Cambridge: The University Press, 1942.

Scheurer, Elizabeth A. *The Continuous Present of Organic Architecture*. Cincinnati: The Contemporary Arts Center, 1991.

Sarah Bonnemaison and Philip Beesley. *On Growth and form: Organic Architecture and Beyond*. Halifax:TUNS Press, 2008.

Olgyay, Victor. *Design with Climate: Bioclimatic Approach to Architectural Regionalism*. Princeton: Princeton University press, 1962.

Weintraub, Alan and Hess, Alan. *Organic Architecture: The Other Modernism*. Layton, Utah: Gibbs Smith, 2006.

Senosiain, Javier. *Bio-Architecture*. Oxford: Architectural Press, 2003.

Wines, James. *Green Architecture*. Italy: Taschen, 2000.

Zevi, Bruno. *Towards an Organic Architecture*. London: Faber & Faber, 1950.

GROUP 2- NATURE AND ARCHITECTURE BOOKS

Blackwood, John. *Geometry in Nature: Exploring the Morphology of Natural World*

through Projective Geometry. Poland: Floris Books, 2012.

Colman, Samuel, and ed., C. Arthur Coan. *Nature's Harmonic Unity: A treatise on its relation to proportional form.* New York: The Knickerbocker Press, 1912.

James, M. Fitch, ed. *Shelter: Models of Native Ingenuity*. New York: Eilert Printing Co., Inc., 1982.

Menin, Sarah, and Flora Samuel. *Nature and Space: Aalto and Lecorbusier*. New York: Routledge, 2003.

Schirmer, Heidemarie, and Dörte Kuhlmann, ed. *Thesis: Ars Imitatur Naturam*. Bauhaus-Universität Weimar: Universitätsverlag, 1998.

Portoghesi, Paolo, and Erika G. Young, trans. *Nature and Architecture*. Italy: Skira, 2000.

Rapoport, Amos and Philip, Wagner, ed. *House Form and Culture*. New York: Prentice-Hall, 1969.

GROUP 3 - THEORY AND PRACTICE BOOKS

Antoniades, Anthony C. *Poetics of Architecture*. New York: Van Nostrand Reihold, 1990.

Hodder, Ian. *Entanged: An Archaeology of the relationships between humans and things*. Singapore: Jonh Wiley and Sons, 2012.

Ingraham, Catherine. *Architecture, Animal, Human: The asymmetrical condition*. New York: Taylor & Francis e-Library, 2005.

Kent, C. Bloomer and Charles W. Moore. *Body, Memory, and Architecture*. Massachusetts: Yale University Press, 1977.

Kepes, Gyorgy. *Structure in Art and in Science*. New York: George Braziller, Inc, 1965.

Leach, Neil, ed. *Rethinking Architecture: A reader in cultural theory*. London: Taylor & Francis e-Library, 2005.

Leyton, Michael. *Shape as Memory: A geometric theory of architecture*. Germany: Birkhäuser – Publishers for Architecture, 2006.

Lucan, Jacques. *Composition, Non-Composition: Architecture and Theory in the Nineteenth and Twentieth Centuries*. Italy: EPFL Press, 2012.

Sala, Nicoletta, ed. *Chaos and Complexity in the Arts and Architecture*. New York: Nova Science Publishers, 2007.

Norberg-Schulz, Chiristian. *Genius Loci, Towards a Phenomenology of Architecture*. New York: Rizzoli,1991.

Read, Herbert. *The Origins of Form in Art*. New York: Horizon Press, 1965.

GROUP 4 – JOURNAL ARTICLES

Joseph, Balu and Kulkarni, S.Y. "Understanding Architetcural Structures Through the Relation of Process to Product: A Critical Comparison of Works by Santiago Calatrava, Pier Luigi Nervi and Frei Otto." *International Journal of Engineering Research and Technology*, Vol.3, No. 5 (2014): 1523-1527.

Leslie, Thomas. "Form as Diagram of Forces: The Equiangular Spiral in the Work of Pier Luigi Nervi." *Journal of Architectural Education*, (2003): 45-54.

Zbašnik-Senegaènik, Martina and Kitek Kuzman, Manja. "Interpretations of Organic Architecture." *Scientific Papers*, Vol. 2, No.22 (2014): 291-299.

CITATIONS

[1] D'Arcy Wentworth Thompson, "Introductory," in *On Growth and Form* (Cambridge: University Press, 1942), 16.

[2] Thompson, "On Growth and Form," 22.

[3] Bruno Zevi, "Meaning and Scope of the Term *Organic* in reference to Architecture," *Towards an Organic Architecture* (London: Faber Faber, 1982), 69-70.

[4] Ibid., 72.

[4] Ibid., 76.

[5] Richard Coyne. *Thinkers for Architects: Derrida for Architects* (New York: Routledge, 2011), 10.

[6] Caroline van Eck. "Classical and Renaissance analogies between architecture and nature," in *Organicism in Nineteenth-Century Architecture: An Inquiry into its theoretical and philosophical background* (Amsterdam: Architecture & Natura Press, 1994), 41.

[7] Caroline van Eck, "Classical and Renaissance Analogies," 41.

[8] Ibid., 41.

[9] Ibid., 45.

[10] Ibid., 46.

[11] Ibid., 89.

[12] Ibid., 91.

[13] Ibid., 111.

[14] Zbasnik-Senegacnik, Martina and Kitek Kuzman, Manja."Interpretations of Organic Architecture", *Scientific Papers,* Vol. 2, No.22 (2014): 291-299.

[15] Sidney K. Robinson, "The Continuous Present of Organic Architecture," in *The*

Continuous Present of Organic Architecture, ed. Elizabeth A. Scheurer (Cincinnati: The Contemporary Arts Center, 1991), 15.

[16] Robinson, "The Continuous Present of Organic Architecture," 18.

[17] Ibid.

[18] Alan Hess, "Organic Architecture Today," in *Organic Architecture: The Other Modernism*, Pho. Alan Weintraub (Salt lake City: Gibbs Smith, 2006), 186

[19] Adolf Loos, "Ornament and Crime," in *Ornament and Crime: Selected Essays*, Riverside, CA: Ariadne Press, 1998), 171.

[20] Walter Gropius, "Standardization," in *The New Architecture and the Bauhaus*, trans. P. Morton Shand, intro. Frank Pick (Cambridge: MIT Press, 1965), 30.

[21] Gropius, "Rationalization," 38.

[22] Juhani Pallasmaa, "Hegemony of The Eye and The Loss of The body," in *Thesis: Ars Imitatur Naturam*, ed. Heidemarie Scheirmer and Dorte Kuhlman (Bauhaus Universitat: Wissenschaftliche Zeitschrift, 1997), 110.

[23] Pallasmaa, "*Thesis: Ars Imitatur Naturam*," 109.

[24] Ibid., 110.

[25] Kenneth Frampton, "Introduction: Reflections on the Scope of the Tectonic," in *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture* (Cambridge: MIT Press, 2001), 8.

[26] Ibd.

[27] John Ruskin, "The Lamp of Truth" in *The Seven Lamps of Architecture* (1849), New York: Farrar, Straus, 1961), 66.

[28] Christian Norberg-Schulz, "Architectural Space," in *Existence, Space and Architecture* (New York: Praeger Publishers, 1971), 37.

[29] Frampton, "*Studies in Tectonic Culture*," 4.

[30] Martin Heidegger, "Building Dwelling Thinking" in *Poetry, Language, Thought*, Trans. and Int. Albert Hofstadter (New York: Harper & Row, 1871), 144.

[31] Ibid.

[32] Ibid., 146.

[33] Ibid., 149.

[34] Amos Rapoport, House Form and Culture (London: Prentice-Hall, Inc., 1969), 49

[35] Victor Olgyay, "Environment and Building Form," in *Design with Climate: Bioclimatic Approach to Architectural Regionalism*, cooper. Aladar Olyay (New Jersey: Princeton, 1952), 62.

[36] Victor Olgyay, "Environment and Building Form,"85.

[37] Olgyay, "Morphology of Town Structures,"91.

[38] Heidegger, "Poetry, Language, Thought," 144.

[39] Ibid.,147.

[40] Ibid.

[41] David Bohm, "Fragmentation and Wholeness," in *Wholeness and the Implicate Order* (New York: Routledge, 2002), 3

[42] Heidegger, "Poetry, Language, Thought," 144.

[44] Ibid, 151.

[45] Ibid., 147.

[46] Ibid.

[47] Andrew W. Charleson, "Relationships between architectural and structural form," in *Structure as Architecture* (London: Elsevier, 2005), 22

[48] Ibid., 22.

[49] Ibid.

[50] Ibid.

[51] Charleson, "Relationships," 25.

[52] Thompson, "The Comparison of Related Forms," 1063-1064.

[53] Paolo Portoghesi, "Nature and Architecture," in *Nature and Architecture* (Italy: Skira, 2000), 11.

[54] Portoghesi, "Nature and Architecture," 14.

[55] Ibid., 15.

[56] Jacques Lucan. "Distribution, Disposition, Composition," in *Composition, Non – Composition: architecture and theory in the nineteenth and twentieth century* (Italy: EPFL Press), 11.

[57] Lucan. "Distribution, Disposition, Composition," 13.

[58] Ibid,19.

[59] Ibid., 20.

[60] Ibid., 22.

[61] Ibid., 25.

[62] Jacques Lucan, "Convex Space: Le Corbusier and the Free Plan," in *Composition, Non – Composition: architecture and theory in the nineteenth and twentieth century* (Italy: EPFL Press), 367.

[63] Anthony C. Antoniades, "The Chanel of Transformation," in *Poetics of Architecture: Theory of Design* (New York: Van Nostrand Reinhold, 1990), 66.